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December 1971

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Volume 12, Number 10, October 1971

Radiological Health Data and Reports, a monthly publication of the Environmental Protection Agency, presents data and reports provided by Federal, State, and foreign governmental agencies, and other cooperating organizations. Pertinent original data and interpretive manuscripts are invited from investigators.

In August 1959, the President directed the Secretary of Health, Education, and Welfare to intensify Departmental activities in the field of radiological health. The Department was assigned responsibility within the Executive Branch for the collation, analysis, and interpretation of data on environmental radiation levels. This responsibility was delegated to the Bureau of Radiological Health, Public Health Service. Pursuant to the Reorganization Plan No. 3 of 1970, effective December 2, 1970, this responsibility was transferred to the Radiation Office of the Environmental Protection Agency which was established by this reorganization.

The Federal agencies listed below appoint their representatives to a Board of Editorial Advisors. Members of the Board advise on general publications policy; secure appropriate data and manuscripts from their agencies; and review those contents which relate to the special functions of their agencies.

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Dr. Joseph A. Lieberman
Deputy Assistant Administrator
for Radiation Programs
Office of Radiation Programs

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ENVIRONMENTAL PROTECTION AGENCY
William D. Ruckelshaus, Administrator

Reports

A Joint X-ray Radiation Survey in Puerto Rico, 1968

Michael Gileadi[1]

The objectives, scope, and methods used in the 1968 Joint Radiation Survey Project, sponsored jointly by the Puerto Rico Nuclear Center and by the Department of Health of the Commonwealth of Puerto Rico, are described. The most significant results concerning the western and southern regions of the island are presented. Most of the three quantifiers (mean gonadal dose, per capita per annum gonadal dose, and genetically significant dose) were smaller in the southern region than those in the western region.

Cognizant of the potential health hazards associated with x-ray exposure, a survey was initiated in Puerto Rico in 1968, to find methods to minimize diagnostic x-ray exposures without interfering with the diagnostic information required. The survey was sponsored jointly by the Department of Health of the Commonwealth of Puerto Rico and the Puerto Rico Nuclear Center.

The primary objective of the project was to evaluate the dose to the patient due to unintentional irradiation of the gonads during abdominal and thoracic diagnostic x-ray examinations. Based on the results of the study, recommendations, compatible with the diagnostic information required, may be made to the owner or operator of the machine to reduce the hazards to a minimum.

Among the several indices designed to characterize the dose to the patient, the following were used in this survey:

1. Mean gonadal dose per diagnostic x-ray examination considered,
2. Per capita per annum gonadal dose due to the diagnostic x-ray examination considered, and
3. Genetically significant dose due to diagnostic x-ray examination considered.

Results of previous research (*1–4*) in this field established the fact that the largest contribution to the genetically significant dose (actually 80 to 90 percent of the total dose to the gonads) is due to a relatively small group of abdominal and pelvic examinations. In accordance with this observation, the following diagnostic x-ray procedures were included in the Puerto Rico survey:

1. abdomen,
2. gallbladder (cholecystography),
3. upper gastrointestinal series,
4. lower gastrointestinal tract (barium enema),
5. lumbar spine,
6. pelvic,
7. hip joint,
8. intravenous pyelography (I.V.P.) or retrograde pyelography, and
9. pelvimetry.

The objective of characterizing the radiation hazards by the three indices enumerated dictated the following scope and order of work in our survey:

1. Careful collection and extensive statistical analysis of such data as:

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[1] Mr. Michael Gileadi is a senior associate with the Puerto Rico Nuclear Center and in charge of the Joint Radiation Survey Project. His present address is the Puerto Rico Nuclear Center, College Station, Mayaguez, Puerto Rico 00708.

    a) The number and geographic distribution of diagnostic x-ray units being operated in Puerto Rico, classified according to ownership, manufacturer and model, total filtration, half value layer (HVL), kilovoltage (kVp), and maximal milliamperage values (mA).
    b) The number of patients served by the unit, and the distribution of patients with respect to sex, age, and type of diagnostic x-ray procedure administered.
2. Determination of the radiation doses associated with each diagnostic procedure considered, and
3. Evaluation and interpretation of the indices enumerated above.

This method of working not only furnished answers to the questions concerning radiation hazards, but also, as a very valuable byproduct, yielded the first census of diagnostic x-ray equipment in Puerto Rico.

Detailed statistical data concerning the number of diagnostic x-ray examinations performed during a specified time interval on a certain unit were collected from the medical institutions and private offices surveyed (*5–6*). In addition, information was collected on the distribution of the examinations with respect to the type of procedure used and the distribution of patients with respect to sex and age groups.

Dose measurements were carried out both in vivo and on a Rando phantom using a variety of methods and instrumentation such as TLD-LiF powder, Victoreen chamber and DuPont SX-249-126 high sensitivity films.[2] Intercalibration of various dosimeters showed reasonable consistency of our dose measurements (*7–8*).

Finally, the dosimetric and statistical data obtained were combined with the vital statistics published by the Department of Health of the Commonwealth and used to compute the characteristic indices.

Data collection and evaluation were made on a regional basis, using the system of the Planning Board of the Commonwealth of Puerto Rico. This plan divides the Island into three regions based on relevant sociocultural and economic factors, as well as natural geographical boundaries. These regions (figure 1) are the following:

1. The northern region, which includes the city of San Juan (the political, cultural and economic capital of the island). The total population of this region is 1,767,200.
2. The southern region, which is highly industrialized with Ponce as the most important city and with a regional population of 493,500.
3. The western region, with Mayaguez as the most important city and with a total regional population of 420,200.

All demographic data quoted above refer to the year 1968.

Portions of the survey covering the western and southern regions (figure 2) were completed

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[2] These films were developed and read in the Health Physics Division of Brookhaven National Laboratory.

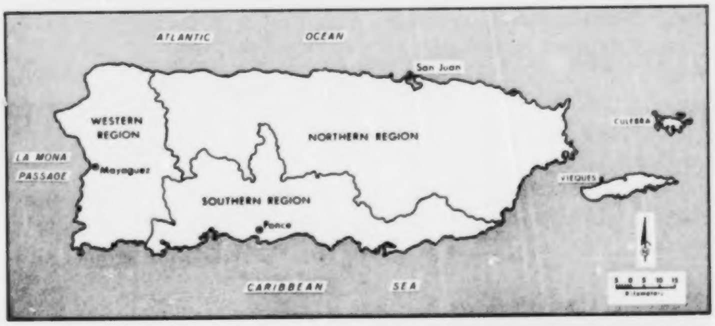

Figure 1. Puerto Rico and its subdivision in regions according to the planning board

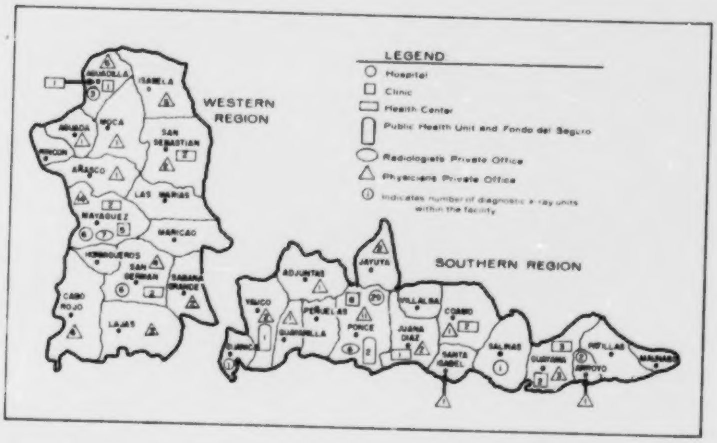
LEGEND
Hospital
Clinic
Health Center
Public Health Unit and Fondo del Seguro
Radiologists Private Office
Physicians Private Office
indicates number of diagnostic x-ray units within the facility
WESTERN REGION
SOUTHERN REGION
AGUADILLA
ISABELA
AGUADA
MOCA
RINCON
SAN SEBASTIAN
AÑASCO
LAS MARIAS
MAYAGUEZ
MARICAO
HORMIGUEROS
SAN GERMAN
SABANA GRANDE
CABO ROJO
LAJAS
ADJUNTAS
JAYUYA
YAUCO
PEÑUELAS
GUAYANILLA
PONCE
GUANICA
VILLALBA
JUANA DIAZ
COAMO
SANTA ISABEL
SALINAS
GUAYAMA
PATILLAS
ARROYO
MAUNABO

Figure 2. Distribution of diagnostic x-ray units in the western and southern regions of Puerto Rico, 1968

by 1969 (*7–8*). Some of the most significant results obtained in the survey are presented herewith.

Table 1 enables one to compare data concerning the southern and western regions in Puerto Rico for 1968. Because of the larger population in the southern region, it is natural that the number of diagnostic x-ray examinations is greater in the southern than in the western region (figures 3 and 4).

Table 1. Comparison of certain significant statistical results obtained in the joint radiation survey of the western and southern regions, Puerto Rico, 1968

Item	Southern region (population 493,500)	Western region (population 420,200)
Number of diagnostic x-ray units (excluding dental x-ray units)	83	78
Total number of abdominal diagnostic x-ray examinations within the "genetically significant" group	48,586	55,364
Total number of all thoracic diagnostic x-ray examinations	105,576	97,258
Total number of diagnostic x-ray examinations in public institutions only[a]	164,370	151,153
Total number of x-ray diagnostic examinations	217,732	215,197
Population per x-ray unit	5,945	5,387
Number of x-ray examinations per 100 patients in public institutions[a]	37.4	34.1

[a] The term "public institution" includes hospitals, clinics, health centers, and public health units.

Table 2 shows characteristic indices relating to radiation dose associated with diagnostic x-ray procedures considered within the southern region and the western region. A brief description of the derivation and interpretation of these indices follows.

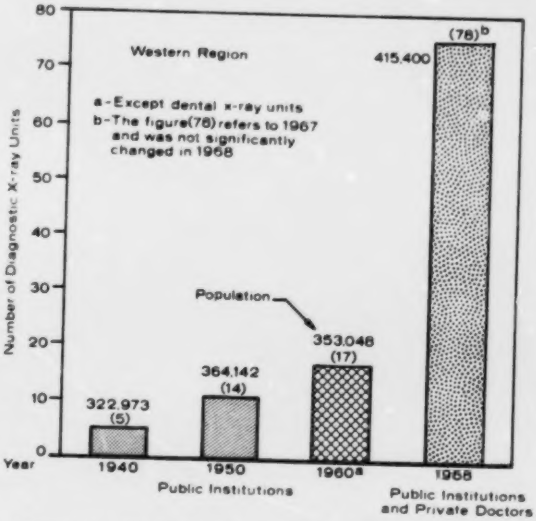

Figure 3. Variation of population and number of diagnostic x-ray units in the western region

The mean gonadal dose per abdominal diagnostic x-ray examination was derived from the measured gonadal dose associated with each type of abdominal diagnostic x-ray examination considered and from the number of such examinations performed annually within the region. The mean gonadal dose was computed as the weighted aver-

5

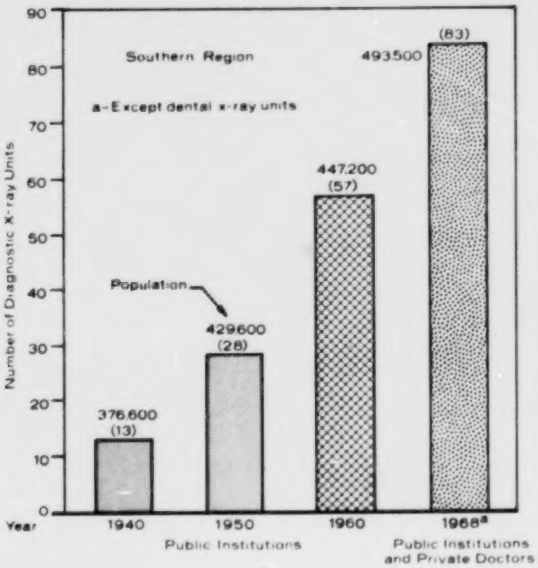

Figure 4. Variation of population and number of diagnostic x-ray units in the southern region

age of the measured doses with the pertinent numbers of diagnostic x-ray examinations used as statistical weights.

The mean gonadal dose thus computed is intended to be an indication of the radiation dose incurred on the average whenever a patient within the specified region (and time interval) undergoes an abdominal diagnostic x-ray test of any kind included within our survey.

The mean gonadal dose per thoracic examination was determined and interpreted in a similar fashion.

The per capita per annum gonadal dose per abdominal diagnostic x-ray examination was derived as follows. Using the measured doses for each abdominal x-ray procedure considered, the gonadal doses associated with diagnostic x-ray examinations delivered to all patients within the region during the specified year were added up and the grand total obtained was divided by the total population of the region.

The per capita per annum gonadal dose per thoracic diagnostic x-ray examination was derived in a similar fashion.

Table 2. Comparison of characteristic indices obtained for the western and southern regions in the radiation survey, Puerto Rico, 1968

Item	Southern region 1968 (population 493,500) (mrem)	Western region 1968 (population 420,200) (mrem)
Mean gonadal dose per abdominal diagnostic x-ray examination	443.6	424.8
Mean gonadal dose per thoracic diagnostic x-ray examination	1.04	1.14
Per capita per annum gonadal dose due to abdominal diagnostic x-ray examination	43.6	56.4
Per capita per annum gonadal dose due to thoracic diagnostic x-ray examination	.25	.26
Genetically significant dose due to diagnostic abdominal x-ray examinations	36.2	48.4
Genetically significant dose due to thoracic x-ray examinations	.2	.2

The genetically significant dose (GSD) was computed by means of the Penfil-Brown formula (*2*) using the dose measurements and detailed statistical data concerning age-sex distribution of patients for each type of examination considered as well as vital statistics of the Department of Health of the Commonwealth. The genetically significant dose characterizes the potential radiation damage imparted via genetic material to an average offspring that will be begotten after exposing the parent's gonads to ionizing radiation.

A survey of the northern region of Puerto Rico is now in process and is scheduled to be completed by the end of fiscal year 1971.

The recently approved survey of dental x-ray units and the possible health hazards associated with their use is proceeding under the joint sponsorship of the Puerto Rico Nuclear Center and the Department of Health of the Commonwealth of Puerto Rico with the cooperation of the School of Dentistry and the University of Puerto Rico.

It is hoped that with further development of social radiology in Puerto Rico, these two surveys will be followed by a general evaluation of hazards due to exposure to ionizing radiation of all kinds (x rays; radioactive sources used in industry, education, science, and medicine; ionizing radiation emitted by various electronic products; etc.) and that all suitable means will be used to reduce this total exposure to an unavoidable minimum.

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SECTION I. MILK AND FOOD

Milk Surveillance, June 1971

Although milk is only one of the sources of dietary intake of environmental radioactivity, it is the food item that is most useful as an indicator of the general population's intake of radionuclide contaminants resulting from environmental releases. Fresh milk is consumed by a large segment of the population and contains several of the biologically important radionuclides that may be released to the environment from nuclear activities. In addition, milk is produced and consumed on a regular basis, is convenient to handle and analyze, and samples representative of general population consumption can be readily obtained. Therefore, milk sampling networks have been found to be an effective mechanism for obtaining information on current radionuclide concentrations and long-term trends. From such information, public health agencies can determine the need for further investigation or corrective public health action.

The Pasteurized Milk Network (PMN) sponsored by the Office of Radiation Programs, Environmental Protection Agency, and the Office of Food Sanitation, Food and Drug Administration, U.S. Public Health Service, consists of 63 sampling stations; 61 located in the United States, one in Puerto Rico, and one in the Canal Zone. Many of the State health departments also conduct local milk surveillance programs which provide more comprehensive coverage within the individual State. Data from 15 of these State networks are reported routinely in *Radiological Health Data and Reports*. Additional networks for the routine surveillance of radioactivity in milk in the Western Hemisphere and their sponsoring organizations are:

Pan American Milk Sampling Program (Pan American Health Organization and U.S. Environmental Protection Agency)—5 sampling stations

Canadian Milk Network (Radiation Protection Division, Canadian Department of National Health and Welfare)—16 sampling stations.

The sampling locations that make up the networks presently reporting in *Radiological Health Data and Reports* are shown in figure 1. Based on the similar purpose for these sampling activities, the present format integrates the complementary data that are routinely obtained by these several milk networks.

Radionuclide and element coverage

Considerable experience has established that relatively few of the many radionuclides that are formed as a result of nuclear fission become incorporated in milk (*1*). Most of the possible radiocontaminants are eliminated by the selective metabolism of the cow, which restricts gastrointestinal uptake and secretion into the milk. The five fission-product radionuclides which commonly occur in milk are strontium-89, strontium-90, iodine-131, cesium-137, and barium-140. A sixth radionuclide, potassium-40, occurs naturally in 0.0118 percent (*2*) abundance of the element potassium, resulting in a specific activity for potassium-40 of 830 pCi/g total potassium.

Two stable elements which are found in milk, calcium and potassium, have been used as a means for assessing the biological behavior of meta-

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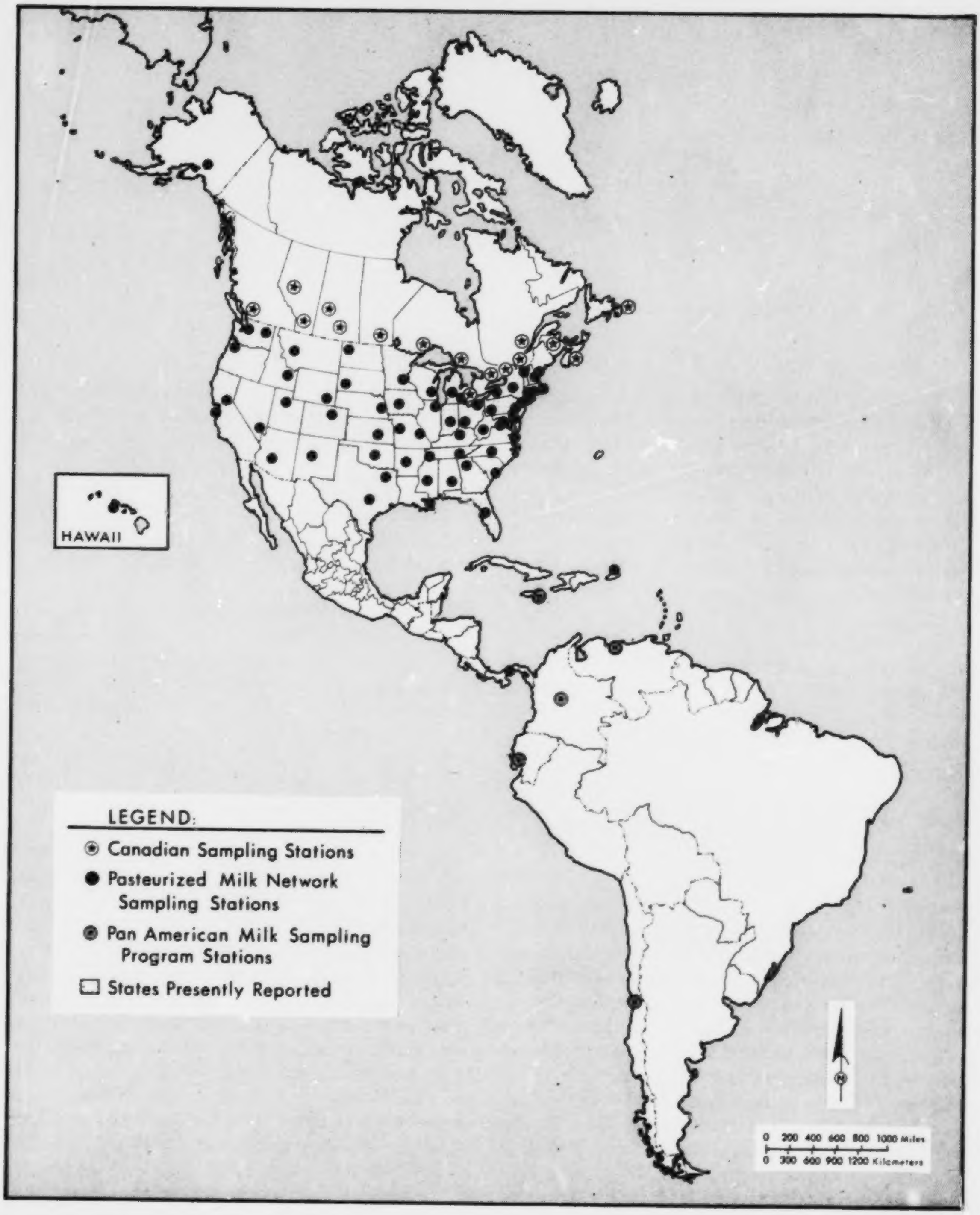
HAWAII
LEGEND:
Canadian Sampling Stations
Pasteurized Milk Network Sampling Stations
Pan American Milk Sampling Program Stations
States Presently Reported
0 200 400 600 800 1000 Miles
0 300 600 900 1200 Kilometers
N

Figure 1. Milk sampling networks in the Western Hemisphere

bolically similar radionuclides (radiostrontium and radiocesium, respectively). The contents of both calcium and potassium in milk have been measured extensively and are relatively constant. Appropriate values and their variations, expressed in terms of 2 standard deviations (2σ), for these elements are 1.16 ± 0.08 g/liter for calcium and 1.51 ± 0.21 g/liter for potassium. These figures are averages of data from the PMN for May 1963–March 1966 (*3*) and were determined for use in general radiological health calculations or discussions.

Accuracy of data from various milk networks

In order to combine data from the international, national, and State networks considered in this report, it was first necessary to determine the accuracy with which each laboratory is making its determinations and the agreement of the measurements among the laboratories. The Analytical Quality Control Service of the Office of Radiation Programs conducts periodic studies to assess the accuracy of determinations of radionuclides in milk performed by interested radiochemical laboratories. The generalized procedure for making such a study has been outlined previously (*4*).

The most recent study was conducted during May–July 1970, with 28 laboratories participating in an experiment on milk samples containing known concentrations of strontium-89, strontium-90, iodine-131, cesium-137, and barium-140 (*5*). Of the 18 laboratories producing data for the networks reporting in *Radiological Health Data and Reports*, 13 participated in the experiment.

The accuracy results of this experiment are shown in table 1. In general, considerable improvement is needed, especially in the accuracy measurements. These possible differences should be kept in mind when considering the integration of data from the various networks.

Development of a common reporting basis

Since the various networks collect and analyze samples differently, a complete understanding of several parameters is useful for interpreting the data. Therefore, the various milk surveillance networks that report regularly were surveyed for information on analytical methods, sampling and analysis frequencies, and estimated analytical errors associated with the data.

In general, radiostrontium is collected by an ion-exchange technique and determined by beta-particle counting in low-background detectors, and the gamma-ray emitters (potassium-40, iodine-131, cesium-137, and barium-140) are determined by gamma-ray spectroscopy of whole milk. Each laboratory has its own modifications and refinements of these basic methodologies. The methods used by each of the networks have been referenced in earlier reports appearing in *Radiological Health Data and Reports.*

Table 1. Distribution of mean results, quality control experiment

Isotope and known concentration		Number of laboratories in each category			
		Acceptable[a]	Warning level[b]	Unacceptable[c]	Total
Strontium 89:	High (258 pCi/liter)	7 (44%)	1 (6%)	8 (50%)	16
	Low (15 pCi/liter)	11 (69%)	3 (19%)	2 (12%)	16
Strontium-90:	Intermediate (79.4 pCi/liter)	13 (57%)	4 (17%)	6 (26%)	23
	Low (32.0 pCi/liter)	5 (25%)	4 (20%)	11 (55%)	20
Iodine-131:	High (507 pCi/liter)	18 (67%)	2 (7%)	7 (26%)	27
	Low (49 pCi/liter)	16 (64%)	3 (12%)	6 (24%)	25
Cesium-137	High (259 pCi/liter)	20 (74%)	3 (11%)	4 (15%)	27
	Low (53 pCi/liter)	17 (66%)	5 (19%)	4 (15%)	26
Barium-140:	High (302 pCi/liter)	18 (67%)	2 (7%)	7 (26%)	27
	Low (33 pCi/liter)	23 (92%)	0	2 (8%)	25

[a] Measured concentration equal to or within 2σ of the known concentration.
[b] Measured concentration outside 2σ and equal to or within 3σ of the known concentration.
[c] Measured concentration outside 3σ of the known concentration.

A previous article (*6*) summarized the criteria used by the State networks in setting up their milk sampling activities and their sample collection procedures as determined during a 1965 survey. This reference and an earlier data article for the particular network of interest may be consulted should events require a more definitive analysis of milk production and milk consumption coverage afforded by a specific network.

Many networks collect and analyze samples on a monthly basis. Some collect samples more frequently but composite the several samples for one analysis, while others carry out their analyses more often than once a month. Many networks are analyzing composite samples on a quarterly basis for certain nuclides. The frequency of collection and analysis varies not only among the networks but also at different stations within some of the networks. In addition, the frequency of collection and analysis is a function of current environmental levels. The number of samples analyzed at a particular sampling station under current conditions is reflected in the data presentation. Current levels for strontium-90 and cesium-137 are relatively stable over short periods of time, and sampling frequency is not critical. For the short-lived radionuclides, particularly iodine-131, the frequency of analysis is critical and is generally increased at the first measurement or recognition of a new influx of this radionuclide.

The data in table 2 show whether raw or pasteurized milk was collected. An analysis (*7*) of raw and pasteurized milk samples collected during January 1964 to June 1966 indicated that for relatively similar milkshed or sampling areas, the differences in concentration of radionuclides in raw and pasteurized milk are not statistically significant (*7*). Particular attention was paid to strontium-90 and cesium-137 in that analysis.

Practical reporting levels were developed by the participating networks, most often based on 2-standard-deviation counting errors or 2-standard-deviation total analytical errors from replicate analyses (*3*). The practical reporting level reflects analytical factors other than statistical radioactivity counting variations and will be used as a practical basis for reporting data.

The following practical reporting levels have been selected for use by all networks whose practical reporting levels were given as equal to or less than the given value.

Radionuclide	Practical reporting level (pCi/liter)
Strontium-89	5
Strontium-90	2
Iodine-131	10
Cesium-137	10
Barium-140	10

Some of the networks gave practical reporting levels greater than those above. In these cases, the larger value is used so that only data considered by the network as meaningful will be presented. The practical reporting levels apply to the handling of individual sample determinations. The treatment of measurements equal to or below these practical reporting levels for calculation purposes, particularly in calculating monthly averages, is discussed in the data presentation.

Analytical error or precision expressed as pCi/liter or percent in a given concentration range have also been reported by the networks (*3*). The precision errors reported for each of the radionuclides fall in the following ranges:

Radionuclide	Analytical errors of precision (2 standard deviations)
Strontium-89	1–5 pCi/liter for levels <50 pCi/liter; 5–10% for levels ≥50 pCi/liter;
Strontium-90	1–2 pCi/liter for levels <20 pCi/liter; 4–10% for levels ≥20 pCi/liter;
Iodine-131 Cesium-137 Barium-140	4–10 pCi/liter for levels <100 pCi/liter; 4–10% for levels ≥100 pCi/liter.

For iodine-131, cesium-137, and barium-140, there is one exception to these precision error ranges: 25 pCi/liter at levels <100 pCi/liter for Colorado. This is reflected in the practical reporting level for the Colorado milk network.

Federation Radiation Council guidance applicable to milk surveillance

In order to place the U.S. data on radioactivity in milk presented in *Radiological Health Data and Reports* in perspective, a summary of the guidance provided by the Federal Radiation Council for specific environmental conditions was presented in the December 1970 issue of *Radiological Health Data and Reports.*

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Table 2. Concentrations of radionuclides in milk for June 1971 and 12-month period, July 1970 through June 1971

Sampling location		Type of sample[a]	Radionuclide concentration (pCi/liter)					
			Strontium-90		Iodine-131		Cesium-137	
			Monthly average[b]	12-month average	Monthly average[b]	12-month average	Monthly average[b]	12-month average
UNITED STATES:								
Ala:	Montgomery[c]	P	NA	7	0	0	0	9
Alaska:	Palmer[c]	P	5	5	0	0	13	13
Ariz:	Phoenix[c]	P	NA	1	0	0	0	0
Ark:	Little Rock[c]	P	12	12	0	0	22	13
Calif:	Sacramento[c]	P	NA	1	0	0	0	0
	San Francisco[c]	P	NA	2	0	0	0	0
	Del Norte	P	20	16	0	0	10	11
	Fresno	P	2	2	0	0	2	1
	Humboldt	P	5	5	0	0	7	4
	Los Angeles	P	2	2	0	0	0	0
	Mendocino	P	6	5	0	0	4	4
	Sacramento	P	3	3	0	0	4	1
	San Diego	P	1	2	0	0	0	0
	Santa Clara	P	2	2	0	0	0	1
	Shasta	P	3	3	0	0	8	3
	Sonoma	P	3	3	0	0	9	3
Colo:	Denver[c]	P	NA	4	0	0	13	4
	West	R	NA		[d]0	[d]0	[d]0	[d]0
	Northeast	R	NA		NS	[d]0	NS	[d]0
	East	R	NA		NS	[d]0	NS	[d]0
	Southeast	R	NA		[d]0	[d]0	[d]0	[d]0
	South Central	R	NA		NS	[d]0	NS	[d]0
	Southwest	R	NA		[d]0	[d]0	25	[d]3
	Northwest	R	NA		[d]0	[d]5	[d]0	[d]0
Conn:	Hartford[c]	P	NA	7	0	0	9	11
	Central	P	8	6	0	0	14	16
Del:	Wilmington[c]	P	NA	9	0	0	13	8
D.C:	Washington[c]	P	NA	7	0	0	14	9
Fla:	Tampa[c]	P	5	5	0	0	43	47
	West	R	14	9	NA	0	NA	15
	North	R	8	9	0	0	27	26
	Northeast	R	NA	6	NA	0	NA	36
	Central	R	4	6	0	0	95	49
	Tampa Bay area	P	4	6	0	0	45	49
	Southeast	R	4	7	0	1	42	78
Ga:	Atlanta[c]	P	NA	11	0	0	16	14
Hawaii:	Honolulu[c]	P	3	3	0	0	0	0
Idaho:	Idaho Falls[c]	P	6	5	0	0	0	8
Ill:	Chicago[c]	P	8	7	0	0	17	11
Ind:	Indianapolis[c]	P	NA	7	0	0	12	8
	Northeast	P	7	9	0	0	20	15
	Southeast	P	7	10	0	0	30	14
	Central	P	6	8	0	5	20	12
	Southwest	P	7	11	0	0	30	12
	Northwest	P	5	10	0	0	20	13
Iowa:	Des Moines[c]	P	NA	7	0	0	15	4
	Iowa City	P	6	7	0	0	13	14
	Des Moines	P	7 (5)	8	0 (5)	0	9 (5)	11
	Spencer	P	8 (2)	6	0 (2)	0	15 (2)	9
	Fredericksburg	P	NS	NS	NS	NS	NS	NS
Kans:	Wichita[c]	P	NS	7	NS	0	NS	3
	Coffeyville	P	11	8	0	3	12	8
	Dodge City	P	7	7	0	0	10	2
	Falls City	R	NS	12	NS	5	NS	8
	Hays	P	9	10	0	4	12	5
	Kansas City	P	10	8	0	3	14	13
	Topeka	P	11	10	0	1	15	12
	Wichita	P	9	11	0	2	16	7
Ky:	Louisville[c]	P	NA	8	0	0	0	2
La:	New Orleans[c]	P	15	14	0	0	19	18
Maine:	Portland[c]	P	NA	10	0	0	19	21
Md:	Baltimore[c]	P	NA	8	0	0	0	7
Mass:	Boston[c]	P	11	9	0	0	15	20
Mich:	Detroit[c]	P	NA	8	0	0	17	11
	Grand Rapids[c]	P	NA	9	0	0	15	15
	Bay City	P	NS	7	NS	0	NS	13
	Charlevoix	P	8	10	[d]0 (5)	[d]1	22 (5)	16
	Detroit	P	7	7	[d]0	[d]0	11	9
	Grand Rapids	P	6	8	[d]0	[d]0	14	10
	Lansing	P	4	8	[d]0 (2)	[d]0	23 (2)	14
	Marquette	P	12	11	[d]0 (2)	[d]0	25 (2)	23
	Monroe	P	5	6	[d]0 (2)	[d]0	6 (2)	4
	South Haven	R	8	7	[d]0 (5)	[d]0	17 (5)	8
Minn:	Minneapolis[c]	P	NA	10	0	0	19	14
	Bemidji	P	9	7	0	0	17	22
	Mankato	P	7	5	0	0	11	11
	Rochester	P	11	7	0	0	15	11
	Duluth	P	23	15	0	0	33	28
	Worthington	P	6	5	0	0	11	0

See footnotes at end of table.

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Table 2. Concentrations of radionuclides in milk for June 1971 and 12-month period, July 1970 through June 1971—Continued

Sampling location		Type of sample[a]	Radionuclide concentration (pCi/liter)					
			Strontium-90		Iodine-131		Cesium-137	
			Monthly average[b]	12-month average	Monthly average[b]	12-month average	Monthly average[b]	12-month average
UNITED STATES—Continued								
Minn:	Minneapolis	P	14	18	0	0	20	17
	Fergus Falls	P	9	6	0	0	16	14
	Little Falls	P	22	15	0	0	31	36
Miss:	Jackson[c]	P	NA	11	0	0	17	10
Mo:	Kansas City[c]	P	NA	7	0	0	12	3
	St. Louis[c]	P	NA	9	0	0	12	5
Mont:	Helena[c]	P	NA	5	0	0	15	11
Nebr:	Omaha[c]	P	NA	5	0	0	0	2
Nev:	Las Vegas[c]	P	NA	3	0	0	0	0
N.H:	Manchester[c]	P	NA	10	0	0	23	23
N.J:	Trenton[c]	P	NA	9	0	0	17	11
N. Mex:	Albuquerque[c]	P	NA	2	0	0	0	0
N.Y:	Buffalo[c]	P	9	7	0	0	0	12
	New York City[c]	P	NA	9	0	0	11	18
	Syracuse[c]	P	NA	7	0	0	0	11
	Albany	P	7	7	0 (4)	0	[d]0 (4)	0
	Buffalo	P	9	0	0	0	[d]0	0
	Massena	P	12	8	0 (3)	0	25 (3)	24
	Newburg	P	5	7	0 (2)	0	[d]0 (2)	0
	New York City	P	7	10	0	0	28	0
	Syracuse	P	3	4	0 (2)	0	[d]0	0
N.C:	Charlotte[c]	P	NA	11	0	0	18	13
N. Dak:	Minot[c]	P	NA	10	0	0	0	9
Ohio:	Cincinnati[c]	P	NA	7	0	0	0	2
	Cleveland[c]	P	NA	8	0	0	0	12
Okla:	Oklahoma City[c]	P	NA	6	0	0	14	7
Oreg:	Portland[c]	P	8	5	0	0	21	5
	Baker	P	NA	3	0	0	0	8
	Coos Bay	P	NA	6	0	0	0	10
	Eugene	P	NA	4	0	0	18	3
	Medford	P	NA	2	0	0	19	9
	Portland composite	P	NA	5	0	0	10 (2)	6
	Portland local	P	NA	4	0	0	10 (2)	9
	Redmond	P	NA	3	0	0	0	2
	Tillamook	P	NA	6	0	0	26	17
Pa:	Philadelphia[c]	P	NA	9	0	0	0	7
	Pittsburgh[c]	P	NA	11	0	0	16	14
	Dauphin	P	NS	6	0	1	18	14
	Erie	P	NS	9	0	0	NS	25
	Philadelphia	P	0	8	0	0	21	16
	Pittsburgh	P	7	12	0	1	15	21
R.I:	Providence[c]	P	NA	8	0	0	23	19
S.C:	Charleston[c]	P	8	9	0	1	24	15
S. Dak:	Rapid City[c]	P	NA	7	0	0	0	4
Tenn:	Chattanooga[c]	P	NA	8	0	0	14	3
	Memphis[c]	P	NA	7	0	0	14	9
	Chattanooga	P	NA	8	0	0	24	16
	Clinton	R	NA	9	0	0	29	17
	Fayetteville	P	NA	11	0	0	12	14
	Knoxville	P	NA	6	0 (3)	0	18 (3)	13
	Nashville	P	NA	6	0	0	17	11
Tex:	Austin[c]	P	NA	1	0	0	0	1
	Dallas[c]	P	NA	5	0	0	11	5
	Amarillo	R	NA		NA		NA	
	Corpus Christi	R	NA		NA		NA	
	El Paso	R	NA		NA		NA	
	Fort Worth	R	NA		NA		NA	
	Harlingen	R	NA		NA		NA	
	Houston	R	NA		NA		NA	
	Lubbock	R	NA		NA		NA	
	Midland	R	NA		NA		NA	
	San Antonio	R	NA		NA		NA	
	Texarkana	R	NA		NA		NA	
	Tyler	R	NA		NA		NA	
	Uvalde	R	NA		NA		NA	
	Wichita Falls	R	NA		NA		NA	
Utah:	Salt Lake City[c]	P	15	5	0	0	31	16
Vt:	Burlington[c]	P	NA	7	0	0	11	15
Va:	Norfolk[c]	P	NA	9	0	0	15	7
Wash:	Seattle[c]	P	NA	5	0	0	0	3
	Spokane[c]	P	NA	6	0	0	15	3
	Benton County	R	NS	1	NS	0	NS	2
	Franklin County	R	0	3	0	0	14	5
	Sandpoint, Idaho	R	17	12	0	0	34	22
	Skagit County	R	10	7	0	0	20	12
W. Va:	Charleston[c]	P	NA	8	0	0	12	8
Wisc:	Milwaukee[c]	P	NA	6	0	0	0	13
Wyo:	Laramie[c]	P	NA	5	0	0	0	1

See footnotes at end of table.

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Table 2. Concentration of radionuclides in milk for June 1971 and 12-month period, July 1970 through June 1971—Continued

Sampling location		Type of sample[a]	Radionuclide concentration (pCi/liter)					
			Strontium-90		Iodine-131		Cesium-137	
			Monthly average[b]	12-month average	Monthly average[b]	12-month average	Monthly average[b]	12-month average
CANADA:								
Alberta:	Calgary	P	8	7	(d)		24	19
	Edmonton	P	6	8	(d)		22	22
British Columbia:								
	Vancouver	P	8	9	(d)		33	23
Manitoba:	Winnipeg	P	8	7	(d)		26	24
New Brunswick:								
	Fredericton	P	11	12	(d)		21	25
Newfoundland:								
	St. John's	P	16	17	(d)		50	32
Nova Scotia:	Halifax	P	9	11	(d)		32	23
Ontario:	Ottawa	P	3	6	(d)		17	16
	Sault Ste. Marie	P	15	14	(d)		31	33
	Thunder Bay	P	9	12	(d)		25	25
	Toronto	P	9	5	(d)		20	12
	Windsor	P	12	5	(d)		15	11
Quebec:	Montreal	P	8	7	(d)		18	20
	Quebec	P	11	10	(d)		21	29
Saskatchewan:								
	Regina	P	7	7	(d)		13	14
	Saskatoon	P	10	9	(d)		19	18
CENTRAL AND SOUTH AMERICA:								
Colombia:	Bogota	P	2	1	0	0	0	1
Chile:	Santiago	P	2	0	0	0	0	0
Ecuador:	Guayaquil	P	0	0	0	0	0	0
Jamaica:	Montego Bay	P	5	4	0	0	60	50
Venezuela:	Caracas	P	0	1	0	0	0	0
Canal Zone:	Cristobal[c]	P	NA	1	0	0	0	10
Puerto Rico:	San Juan[c]	P	NA	4	0	0	14	11
PMN network average[f]			9	7	0	0	11	9

[a] P, pasteurized milk.
R, raw milk.

[b] When an individual sampling result was equal to or less than the practical reporting level, a value of "0" was used for averaging. Monthly averages less than the practical reporting level reflect the fact that some but not all of the individual samples making up the average contained levels greater than the practical reporting level. When more than one analysis was made in a monthly period, the number of samples in the monthly average is given in parentheses.

[c] Pasteurized Milk Network station. All other sampling locations are part of the State or National network.

[d] Radionuclide analysis not routinely performed.

[e] The practical reporting levels for these networks differ from the general ones given in the text. Sampling results for the networks were equal to or less than the following practical reporting levels:

Iodine-131: Colorado—25 pCi/liter
Michigan—14 pCi/liter
Oregon—15 pCi/liter

Cesium-137: Colorado—25 pCi/liter
New York—20 pCi/liter
Oregon—15 pCi/liter

Strontium-90: New York—3 pCi/liter

[f] This entry gives the average radionuclides concentrations for the Pasteurized Milk Network stations denoted by footnote [c].
NA, no analysis.
NS, no sample collected.

Data reporting format

Table 2 presents the integrated results of the international, national, and State networks discussed earlier. Column 1 lists all the stations which are routinely reported to *Radiological Health Data and Reports*. The relationship between the PMN stations and the State stations is shown in figure 2. The first column under each of the reported radionuclides gives the monthly average for the station and the number of samples analyzed in that month in parentheses. When an individual sampling result is equal to or below the practical reporting level for the radionuclide, a value of zero is used for averaging. Monthly averages are calculated using the above convention. Averages which are equal to or less than the practical reporting levels reflect the presence of radioactivity in some of the individual samples greater than the practical reporting level.

The second column under each of the radionuclides reported gives the 12-month average for the station as calculated from the preceding 12 monthly averages, giving each monthly average equal weight. Since the daily intake of radioactivity by exposed populations groups, averaged over a year, constitutes an appropriate criterion for the case where the FRC radiation protection guides apply, the 12-month average serves as a basis for comparison.

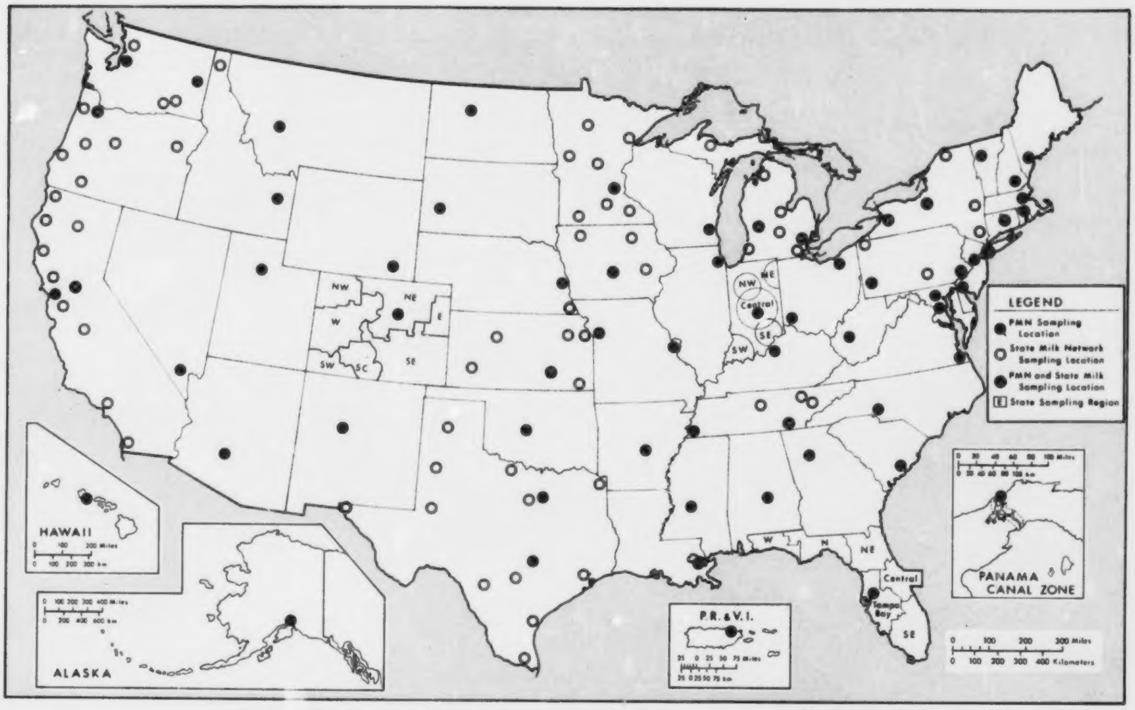

Figure 2. State and PMN milk sampling locations in the United States

Discussion of current data

In table 2, surveillance results are given for strontium-90, iodine-131, and cesium-137 for June 1971 and the 12-month period, July 1970 through June 1971. Except where noted, the monthly average represents a single sample for the sampling station. Strontium-89 and barium-140 data have been omitted from table 2 since levels at the great majority of the stations for June 1971 were below the respective practical reporting levels. Table 3 gives monthly averages for those stations at which strontium-89 or barium-140 was detected. The increase in the levels of strontium-89 at Santiago, Chile, is attributed to the recent French nuclear tests in the Pacific.

Iodine-131 results are included in the table, even though they were generally below practical reporting levels. Because of the lower guide levels established by the Federal Radiation Council, levels in milk for this radionuclide are of particular public health interest. In general, the practical reporting level for iodine-131 is numerically equal to the upper value of Range I (10 pCi/liter) of the FRC radiation protection guide.

Strontium-90 monthly averages ranged from 0 to 23 pCi/liter in the United States for June 1971, and the highest 12-month average was 18 pCi/liter (Minneapolis, Minn.) representing 9.0 percent of the Federal Radiation Council radiation protection guide. Cesium-137 monthly averages ranged from

Table 3. Strontium-89 and barium-140 in milk, June 1971

Sampling location		Radionuclide concentration (pCi/liter)	
		Strontium-89	Barium-140
Ark:	Little Rock (PMN)	6	
Calif:	Del Norte (State)	7	
	Humboldt (State)	6	
	Mendocino (State)	6	
	Shasta (State)	6	
	Sonoma (State)	6	
Ill:	Chicago (PMN)	9	
Kans:	Coffeyville (State)	10	
	Hays (State)	11	
	Kansas City (State)	8	
	Topeka (State)	17	13
	Wichita (State)	11	
Mass:	Boston (PMN)	6	
N.Y.:	Syracuse (State)	6	
Oreg:	Portland (PMN)	8	
Chile:	Santiago (PAHO)	[a]57	

[a] Attributed to French nuclear tests in the Pacific.

0 to 95 pCi/liter in the United States for June 1971, and the highest 12-month average was 78 pCi/liter (Southeast Florida), representing 2.2 percent of the value derived from the recommendations given in the Federal Radiation Council report. Of particular interest are the consistently higher cesium-137 levels that have been observed in Florida (*8*) and Jamaica.

Acknowledgment

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Bureau of Radiological Health
Division of Environmental Sanitation
California State Department of Health

Radiation Protection Division
Canadian Department of National Health
and Welfare

Radiological Health Section
Division of Occupational and Radiological
Health
Colorado Department of Health

Radiological Health Services
Division of Medical Services
Connecticut State Department of Health

Radiological and Occupational Health Section
Department of Health and Rehabilitative
Services
State of Florida

Bureau of Environmental Sanitation
Division of Sanitary Engineering
Indiana State Board of Health

Division of Radiological Health
Environmental Engineering Services
Iowa State Department of Health

Radiation Control Section
Environmental Health Division
Kansas State Department of Health

Radiological Health Services
Division of Occupational Health
Michigan Department of Health

Radiation Control Section
Division of Environmental Health
State of Minnesota Department of Health

Bureau of Radiological Pollution Control
New York State Department of
Environmental Conservation

Environmental Radiation Surveillance Program
Division of Sanitation and Engineering
Oregon State Board of Health

Radiological Health Section
Bureau of Environmental Health
Pennsylvania Department of Public Health

Radiological Health Services
Division of Preventable Diseases
Tennessee Department of Public Health

Division of Occupational Health
Environmental Health Services
Texas State Department of Health

Radiation Control Section
Division of Health
Washington Department of Social and
Health Services

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Food and Diet Surveillance

Efforts are being made by various Federal and State agencies to estimate the dietary intake of selected radionuclides on a continuing basis. These estimates, along with the guidance developed by the Federal Radiation Council, provide a basis for evaluating the significance of radioactivity in foods and diet.

Networks presently in operation and reported routinely include those listed below. These networks provide data useful for developing estimates of nationwide dietary intakes of radionuclides. Programs reported in *Radiological Health Data and Reports* are as follows:

Program	Period reported	Issue
California Diet Study	January–June 1970	November 1970
Carbon-14 in Total Diet and Milk	July–December 1970	May 1971
Connecticut Standard Diet	July–December 1969	December 1970
Radionuclides in Institutional Diet Samples	January–March 1971	September 1971
Strontium-90 in Tri-City Diets	January–December 1969	June 1970

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SECTION II. WATER

The Environmental Protection Agency and other Federal, State, and local agencies operate extensive water quality sampling and analysis programs for surface, ground, and treated water. Most of these programs include determinations of gross beta and gross alpha radioactivity and specific radionuclides.

Although the determination of the total radionuclide intake from all sources is of primary importance, a measure of the public health importance of radioactivity levels in water can be obtained by comparison of the observed values with the Public Health Service Drinking Water Standards (*1*). These standards, based on consideration of Federal Radiation Council (FRC) recommendations (*2–4*) set the limits for approval of a drinking water supply containing radium-226 and strontium-90 at 3 pCi/liter and 10 pCi/liter, respectively. Higher concentrations may be acceptable if the total intake of radioactivity from all sources remains within the guides recommended by FRC for control action. In the known absence[1] of strontium-90 and alpha-particle emitters, the limit is 1,000 pCi/liter gross beta radioactivity, except when additional analysis indicates that concentrations of radionuclides are not likely to cause exposures greater than the limits indicated by the Radiation Protection Guides. Surveillance data from a number of Federal and State programs are published periodically to show current and long-range trends. Water sampling activities reported in *Radiological Health Data and Reports* are listed below.

Water sampling program	Period reported	Issue
California	January–December 1969	October 1971
Gross Radioactivity in Surface Waters of the United States	February 1971	October 1971
Interstate Carrier Drinking Water	1970	July 1971
Kansas	January–December 1969	September 1970
Minnesota	July–December 1969	May 1971
North Carolina	January–December 1967	May 1969
New York	July–December 1969 and January–June 1970	September 1971
Radiostrontium in Tap Water, *HASL*	July–December 1970	October 1971
Tritium in Community Water Supplies	1969	December 1970
Tritium Surveillance System	January–March 1971	July 1971
Washington	July 1968–June 1969	February 1971

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[1] Absence is taken to mean a negligibly small fraction of the specific limits of 3 pCi/liter and 10 pCi/liter for unidentified alpha-particle emitters and strontium-90, respectively.

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Gross Radioactivity in Surface Waters of the United States, February 1971

Office of Water Programs
Environmental Protection Agency

The monitoring of gross radioactivity in surface waters of the United States was begun in 1957 as part of the Water Pollution Surveillance System formerly National Water Quality Network) of the Public Health Service. Currently, the program is operated by the Environmental Protection Agency, Office of Water Programs. Regional offices of the Environmental Protection Agency are responsible for the collection of samples and the entering of the resulting data into the analytical storage and retrieval system. Radioactivity analyses are performed in the centralized radioactivity laboratories of the Office of Water Programs (Cincinnati, Ohio).

Table 1 presents the gross alpha and beta results for samples collected from four rivers during February 1971. The analytical procedures used for determining gross alpha and beta radioactivity are described in the 13th Edition of "Standard Methods for the Examination of Water and Wastewater" (*1*). Results are reported for the date of counting and are not corrected by extrapolation to the date of collection. The sensitivity in counting is that defined by the National Bureau of Standards, Handbook 86 (*2*) and is calculated to be <0.2 pCi/liter for gross alpha and <1 pCi/liter for gross beta radioactivity measurements.

Table 1. Gross radioactivity in U.S. surface waters, February 1971

River and station	Number of grab samples[a]	Gross alpha radioactivity (pCi/liter)		Gross beta radioactivity (pCi/liter)	
		Suspended solids	Dissolved solids	Suspended solids	Dissolved solids
Clinch River: Kingston, Tenn.	3	(<0.2, <0.2) <0.2	(<0.2, 2) <0.8	(<1, 1) <1	(9, 11) 10
Ohio River: Cincinnati, Ohio	1	<0.2	<0.2	1	3
Roanoke River: John Kerr Dam	2	(<0.2, <0.2) <0.2	(<0.2, 1) <0.6	(1, 1) <1	(4, 4) 4
St. Lawrence River: Massena, N.Y.	3	(<0.2, <0.2) <0.2	(<0.2, <0.2) <0.2	(<1, <1) <1	(6, 6) 6

[a] Where more than one sample is analyzed, the minimum and maximum values are in parentheses.

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(*1*) AMERICAN PUBLIC HEALTH ASSOCIATION; AMERICAN WATER WORKS ASSOCIATION AND WATER POLLUTION CONTROL FEDERATION. Standard methods for the examination of water and wastewater, 13th Edition. New York, N.Y. (1971).

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Radioactivity in California Waters,[1] January-December 1969

Bureau of Radiological Health, State of California
Department of Public Health

Gross beta radioactivity in California domestic waters is monitored by the Sanitation and Radiation Laboratory of the State Department of Public Health. The importance of this program in the State's environmental surveillance activities stems from the fact that most of California's domestic water supplies are of surface origin.

Radioactivity in such water supplies consists of the natural radioactivity in surface streams, radioactivity added by the discharge of sewage or by industrial waste effluents, and radioactivity from fallout, particularly fallout into open terminal or distribution reservoirs. Present efforts consist of sampling raw and treated surface waters and well waters (table 1). It should be noted that except for large metropolitan water supplies, raw water sampling is being phased out and treated water sampling being substituted or continued. This procedural change is predicated upon sampling water at the point of consumption.

Most of the supplies sampled have raw surface waters (figure 1) as their source, although a few wells, along with some water supplies that use infiltration galleries, are also sampled.

Monitoring of domestic water supplies is on a continuing basis, since it has not been possible to forecast levels of radioactivity in these supplies based upon levels in rain, snow, or surface streams. Under the present sampling schedule, monthly 500 ml samples are collected, and the total solids analyzed for alpha and beta radioactivity. In addition, 3-liter samples are collected monthly for approximately 6 months and composited for specific radionuclide analysis on a semiannual basis.

Analytical procedures

Radionuclide analyses of water are carried out in the State's Sanitation and Radiation Laboratory. Measurements of alpha and alpha-plus-beta radioactivities are made with a low-background windowless gas-flow proportional counter. Counting methods used follow those recommended by the U.S. Public Health Service (*1*).

Individual samples are evaporated to dryness and the residue ashed at 450°C. The ashed sample is dissolved and transferred to an aluminum planchet for beta-particle counting. Radioisotopic analyses are determined semiannually on composite samples. Gamma-ray emitting nuclides are determined by gamma-ray spectroscopy and radium and radiostrontium by chemical separation and counting.

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[1] Data from July and October 1969 issues of Radiological Health News, State of California, Department of Public Health, Bureau of Radiological Health, 2151 Berkeley Way, Berkeley, Calif. 94704.

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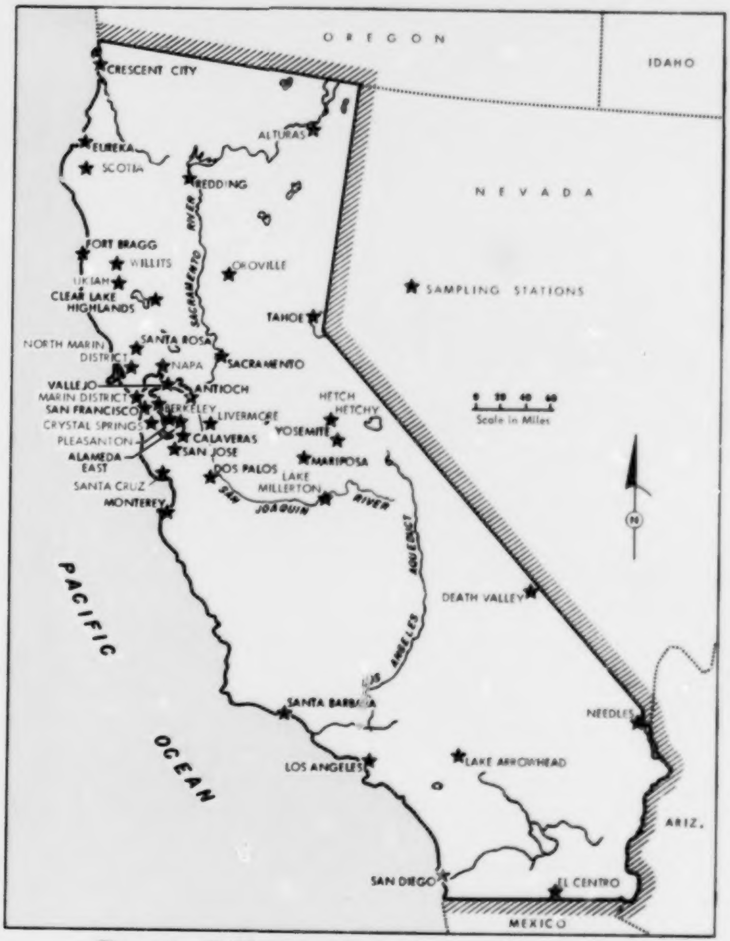
OREGON
IDAHO
NEVADA
CRESCENT CITY
ALTURAS
EUREKA
SCOTIA
REDDING
SACRAMENTO RIVER
FORT BRAGG
WILLITS
OROVILLE
UKIAH
CLEAR LAKE HIGHLANDS
SAMPLING STATIONS
TAHOE
NORTH MARIN DISTRICT
SANTA ROSA
NAPA
SACRAMENTO
VALLEJO
MARIN DISTRICT
SAN FRANCISCO
CRYSTAL SPRINGS
PLEASANTON
ALAMEDA EAST
SANTA CRUZ
MONTEREY
ANTIOCH
BERKELEY
LIVERMORE
CALAVERAS
SAN JOSE
HETCH HETCHY
YOSEMITE
MARIPOSA
DOS PALOS
LAKE MILLERTON
SAN JOAQUIN RIVER
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OCEAN
AQUEDUCT
LOS ANGELES
DEATH VALLEY
SANTA BARBARA
NEEDLES
LOS ANGELES
LAKE ARROWHEAD
ARIZ.
SAN DIEGO
EL CENTRO
MEXICO

Figure 1. California surface water sampling stations

Sewage samples

Sewage samples are collected from many treatment plants throughout the State. Analyses of sewage effluent and sludge samples provide a means of monitoring to insure that industrial radioactive wastes discharged into sewage systems do not become excessive. The surveillance of sewage assumes greater importance as isotope licensees become more numerous and as the quantity per user increases. Analysis procedures for sewage samples are the same as the method used for domestic water. Gross radioactivity in sewage samples for January–December 1969 is presented in table 2.

The relationship between domestic water and sewage is of significance. One would expect a one-to-one radiological relationship between them unless there was some disposal of radioactive material into the sewage. The sewage to domestic water ratio has been calculated for those places where both samples are collected and analyzed. The data are in table 3. In addition to the ratio, the difference in the concentration of radioactive material in sewage and water was determined.

Looking at either the sewage-water ratio or the difference, it is apparent that some sewages in the State contain no additional radioactivity in the sewage as compared to its domestic water, and

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Table 1. Gross beta radioactivity in California domestic waters, January–December 1969

Sampling station	Quality	Concentration[a] (pCi/liter)											
		Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Alturas	Well	31	13	8	0	0	10	8	5	17	15	NS	20
Antioch	Treated	19	17	0	8	0	0	NS	NS	2	10	NS	NS
Lake Arrowhead	Treated	25	7	10	NS	NS	NS	0	NS	NS	6	13	17
Berkeley	Treated	7	7	0	7	8	5	8	NS	7	0	2	22
Clearlake Highlands	Treated	1	28	3	12	10	9	NS	0	1	26	0	20
Crescent City	Well	0	0	1	7	0	3	3	0	NS	0	NS	2
Death Valley	Treated	32	1	16	16	4	NS	NS	NS	NS	NS	NS	35
Dos Palos	Treated	0	0	9	13	0	19	0	0	8	8	0	1
El Centro	Treated	NS	NS	NS	NS	NS	NS	NS	NS	11	18	NS	NS
Eureka	Raw	0	0	1	4	0	6	5	8	0	1	0	0
	Treated	5	42	14	0	8	18	NS	NS	NS	NS	NS	NS
Livermore	Well	NS	NS	NS	NS	6	0	4	NS	7	0	0	10
Los Angeles	Raw	NS	NS	19	NS	1	0	0	30	20	3	21	6
Marin Municipal Water District	Treated	13	35	3	2	0	5	5	3	6	9	0	0
Metropolitan Water District of Southern Calif.	Treated	28	28	0	25	18	19	51	96	36	35	30	21
Lake Millerton	Raw	7	2	0	14	0	7	5	NS	5	10	6	NS
Monterey	Treated	14	0	7	0	7	1	NS	2	NS	5	20	10
Napa	Treated	11	6	NS	NS	0	8	10	NS	13	12	0	13
Needles	Well	NS	NS	14	NS	NS	2	8	5	10	NS	NS	NS
North Marin Water District	Treated	6	NS	NS	9	2	19	NS	NS	NS	NS	NS	NS
	Raw	11	0	7	NS	NS	NS	13	NS	0	6	19	13
	Sludge[b]	16	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Oroville	Treated	0	12	4	10	7	5	NS	NS	0	NS	NS	NS
Wyandotte Irrigation District	Raw	NS	NS	NS	NS	NS	NS	0	NS	14	4	NS	NS
	Treated	NS	NS	NS	NS	NS	NS	NS	NS	0	NS	23	12
Pleasanton	Well	0	7	15	3	2	8	NS	NS	NS	NS	NS	NS
	Treated	NS	NS	NS	NS	NS	NS	5	3	4	0	0	16
Redding	Treated	17	7	6	11	10	44	0	4	3	0	0	13
Sacramento:													
American River	Treated	0	8	NS	11	0	NS	NS	NS	NS	NS	NS	NS
Sacramento	Treated	8	1	NS	11	4	NS	8	NS	0	17	13	NS
San Diego	Raw	0	0	7	24	23	3	8	NS	NS	NS	NS	NS
	Treated	23	10	NS	18	14	23	0	NS	NS	NS	NS	NS
San Francisco	Raw	6	4	80	10	10	0	NS	9	11	11	0	14
San Jose	Raw	0	NS	14	0	7	9	0	8	0	2	14	NS
Santa Barbara	Treated	0	9	20	12	6	7	6	2	14	14	0	0
Santa Cruz	Raw	0	0	0	0	0	5	0	0	8	1	0	0
	Treated	NS	NS	NS	NS	NS	NS	11	15	14	3	11	8
Santa Rosa	Well	NS	NS	NS	2	11	6	6	3	3	0	0	0
Scotia	Treated	6	11	22	6	7	20	NS	9	0	5	NS	NS
Tahoe City	Raw	NS	7	9	3	NS	NS	0	NS	NS	NS	NS	NS
Ukiah	Well	0	7	0	5	0	NS	8	7	11	1	23	NS
Vallejo	Treated	15	0	1	7	0	0	18	15	31	0	10	23
Willits	Treated	15	32	5	0	0	5	4	11	7	2	3	8
Yosemite	Treated	29	0	19	16	0	3	1	11	20	16	NS	9
Maximum		32	42	80	25	23	44	51	96	36	35	30	35
Minimum		0	0	0	0	0	0	0	0	0	0	0	0

[a] Levels below the practical reporting level (15 pCi/liter) should be regarded as statistically insignificant.
[b] Sludge reported in pCi/g (dry weight).
NS, no sample.

some sewages do contain additional radioactive material.

Tables 4 and 5 show a comparison of gross beta yearly average concentrations in sewage effluent and sludge for 1964 through 1969.

Discussion

Table 1 shows the monthly average beta radioactivity in the suspended-plus-dissolved solids in surface water supplies in California for January–December 1969. Following treatment, these waters are used for industrial and domestic purposes. Because alpha radioactivity in water has, in general, been undetectable or very slight, alpha radioactivity analyses are not presented. No increase in radioactivity level of surface water has been observed.

REFERENCE

(*1*) PUBLIC HEALTH SERVICE, DIVISION OF RADIOLOGICAL HEALTH. Radionuclide analyses of environmental samples, R 59-6. Radiological Health Research Activities, Robert A. Taft Sanitary Engineering Center, Cincinnati, Ohio 45226 (November 15, 1959).

Recent coverage in *Radiological Health Data and Reports*

Period	Issue
July–December 1968	August 1970

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Table 2. Gross radioactivity in California sewage samples, January-December 1969

Sewage treatment plant	Concentration (pCi/liter)											
	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Antioch:												
Effluent:												
Alpha	0	1	6	0	0	0	NS	NS	NS	1	NS	0
Beta	0	0	36	29	0	0	NS	NS	NS	4	NS	0
Sludge:												
Alpha	0	20	0	1	9	10	NS	NS	NS	5	7	2
Beta	24	0	15	41	0	0	NS	NS	NS	9	6	15
Bakersfield:												
Effluent:												
Alpha	3	1	0	0	0	0	0	1	1	0	0	0
Beta	0	0	18	35	5	0	2	26	15	0	21	1
Sludge:												
Alpha	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Beta	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
El Centro:												
Effluent:												
Alpha	13	0	22	0	6	5	NS	0	18	0	2	0
Beta	28	9	1	10	8	0	NS	10	0	28	2	2
Sludge:												
Alpha	41	20	17	10	10	26	27	17	29	6	20	29
Beta	27	91	27	14	9	23	31	43	33	22	29	14
Eureka[a]												
Effluent:												
Alpha	1	5	NS	0	NS	NS	13	0	4	NS	NS	NS
Beta	0	0	NS	20	NS	NS	57	19	0	NS	NS	NS
Sludge:												
Alpha	14	3	0	7	NS	NS	3	0	2	NS	NS	NS
Beta	0	67	0	27	NS	NS	0	7	1	NS	NS	NS
Fresno:												
Effluent:												
Alpha	2	4	0	5	1	2	2	1	1	0	1	0
Beta	0	20	2	0	6	0	0	48	10	61	40	27
Sludge:												
Alpha	8	18	25	11	0	13	13	12	4	13	7	14
Beta	0	15	13	25	5	39	52	13	27	2	26	29
Livermore:												
Effluent:												
Alpha	0	0	0	6	2	0	0	0	0	0	2	3
Beta	4	0	19	9	6	21	21	43	70	20	37	40
Sludge:												
Alpha	6	12	14	6	21	8	8	11	0	17	13	44
Beta	141	52	23	102	417	235	243	218	539	16	185	401
Los Angeles City:												
Hyperion:												
Effluent:												
Alpha	5	16	22	9	13	11	18	0	0	5	2	4
Beta	0	10	33	18	12	20	50	31	20	1	8	13
Sludge:												
Alpha	9	8	15	10	11	15	12	3	12	0	5	10
Beta	14	11	10	7	19	0	4	19	19	25	31	28
Los Angeles County:												
Sanitary District:												
Effluent:												
Alpha	0	0	0	9	0	0	0	0	0	NS	4	13
Beta	0	0	28	17	18	0	0	26	28	NS	58	26
Sludge:												
Alpha	10	12	11	4	3	6	7	NS	2	9	18	5
Beta	6	27	11	13	1	0	22	NS	18	23	17	0
Oakland-East Bay mud:												
Effluent:												
Alpha	NS	0	NS	NS	0	NS	NS	0	0	0	0	5
Beta	NS	0	NS	NS	52	NS	NS	37	7	0	8	41
Sludge:												
Alpha	NS	17	NS	NS	12	NS	NS	0	8	NS	13	NS
Beta	NS	16	NS	NS	10	NS	NS	21	16	NS	18	NS
Orange County:												
Plant 1:												
Effluent:												
Alpha	2	0	0	11	17	3	0	0	NS	NS	NS	NS
Beta	0	54	55	17	0	20	36	42	NS	NS	NS	NS
Sludge:												
Alpha	28	18	5	21	15	4	7	0	NS	NS	NS	NS
Beta	20	0	18	0	23	0	1	25	NS	NS	NS	NS
Orange County:												
Plant 2:												
Effluent:												
Alpha	11	0	7	4	35	3	7	2	NS	NS	NS	NS
Beta	8	29	0	30	1	1	35	16	NS	NS	NS	NS

See footnotes at end of table.

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Table 2. Gross radioactivity in California sewage samples, January–December 1969—Continued

Sewage treatment plant	Concentration (pCi/liter)											
	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Orange County:												
Plant 2: (Continued)												
Sludge:												
Alpha	26	12	5	39	18	12	9	18	NS	NS	NS	NS
Beta	0	24	18	0	35	9	3	56	NS	NS	NS	NS
Pleasanton:[a]												
Effluent:												
Alpha	5	20	7	2	2	5	7	4	6	14	5	0
Beta	29	24	55	23	14	19	45	69	37	98	62	133
Sludge:												
Alpha	109	102	71	85	80	72	67	49	47	33	56	53
Beta	171	113	121	192	313	217	160	222	354	363	418	276
Sacramento:												
Effluent:												
Alpha	0	0	16	2	1	0	4	1	NS	0	8	1
Beta	0	0	36	3	16	0	0	22	NS	1	2	12
Sludge:												
Alpha	29	17	3	7	7	12	8	5	NS	11	4	13
Beta	8	15	17	15	3	10	20	28	NS	19	14	23
Salinas:												
Effluent:												
Alpha	0	4	48	10	12	0	0	0	0	8	17	2
Beta	15	0	0	4	0	41	41	53	46	13	41	18
Sludge:												
Alpha	19	61	10	8	17	7	8	13	15	6	8	9
Beta	16	0	38	0	13	16	24	19	72	25	47	30
San Bernardino:												
Effluent:												
Alpha	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Beta	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Sludge:												
Alpha	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Beta	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
San Diego:												
Effluent:												
Alpha	13	10	1	1	2	13	0	1	5	NS	1	15
Beta	0	13	42	23	4	21	36	21	84	NS	34	44
Sludge:												
Alpha	NS	6	0	15	22	14	14	14	16	NS	30	17
Beta	NS	11	3	30	42	13	26	35	20	NS	40	7
San Francisco:												
North Point:												
Effluent:												
Alpha	12	0	0	0	7	2	0	0	35	0	0	0
Beta	13	27	0	22	27	8	23	10	46	34	67	12
Sludge:												
Alpha	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Beta	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Richmond Sunset:												
Effluent:												
Alpha	0	6	0	0	0	0	0	0	0	0	0	0
Beta	0	0	26	10	55	0	0	9	17	8	11	0
Sludge:												
Alpha	13	5	4	6	4	9	9	21	0	NS	9	11
Beta	0	34	15	15	10	0	4	35	23	NS	39	13
Southeast:												
Effluent:												
Alpha	0	12	19	0	0	0	0	0	0	1	0	19
Beta	23	38	26	24	19	25	40	0	0	24	0	42
Sludge:												
Alpha	19	15	3	7	0	19	NS	14	13	NS	3	NS
Beta	15	34	25	18	26	0	NS	15	18	NS	8	NS
San Jose:												
Effluent:												
Alpha	NS	42	NS	1	14	8	NS	0	0	NS	2	NS
Beta	NS	1	NS	1	20	5	NS	5	11	NS	18	NS
Sludge:												
Alpha	NS	12	NS	16	10	59	59	24	9	NS	NS	13
Beta	NS	84	NS	154	215	412	478	223	8	NS	NS	25
Vallejo:												
Effluent:												
Alpha	0	11	2	6	1	0	1	1	0	0	10	0
Beta	20	52	50	23	12	8	26	6	38	12	14	7
Sludge:												
Alpha	6	7	6	13	3	6	22	2	4	3	11	3
Beta	9	8	9	0	9	10	6	0	20	0	24	0

[a] Average of Hill, McCullen, and Murray Street treatment plants.
[b] Average of triplicate samples.
NS, no sample.

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Table 3. Comparison of gross beta radioactivity in domestic water and sewage effluent in California, 1969

Sampling station	Average concentration (pCi/liter)			Sewage to water ratio
	Domestic water	Sewage effluent	Difference	
Antioch	7	9	2	1.3
East Bay mud	7	20	13	2.9
Eureka	10	16	6	1.6
Livermore	4	24	20	6.0
Los Angeles City	13	18	5	1.4
Pleasanton	5	51	46	10.2
Sacramento	6	8	2	1.3
San Diego	9	29	20	3.2
San Francisco:				
North Point	12	24	12	2.0
Richmond Sunset	12	12	0	1.0
South East	12	22	10	1.8
San Jose	7	9	2	1.3
Vallejo	7	22	15	3.1

Table 4. Gross beta radioactivity in California sewage effluent, 1964–1969

Treatment plant	Average concentration (pCi/liter)						6-year-average
	1964	1965	1966	1967	1969	1969	
Antioch	35	15	8	14	3	9	14
Bakersfield	47	41	2	18	9	10	21
El Centro	18	11	15	29	24	9	18
Eureka	89	23	9	7	9	16	26
Fresno	15	25	7	8	12	18	14
Livermore	22	35	29	24	32	24	28
Los Angeles City:							
Hyperion	18	NS	18	20	12	18	18
Los Angeles County	20	29	30	38	19	18	31
East Bay mud	29	28	27	14	27	20	24
Orange County:							
Plant 1	33	25	19	37	21	28	27
Plant 2	95	30	22	36	25	15	37
Pleasanton	124	34	33	29	21	51	49
Sacramento	19	7	8	21	22	8	14
Salinas	16	12	20	NS	11	23	18
San Diego	36	26	48	36	NS	29	37
San Francisco:							
North Point	45	11	18	25	12	24	23
Richmond Sunset	28	15	20	9	11	12	16
Southeast	67	70	38	46	28	22	45
San Jose	26	23	17	12	31	9	20
Vallejo	26	17	16	12	13	22	18

NS, no sample.

Table 5. Gross beta radioactivity in sludge in California sewage treatment plants, 1964–1969

Treatment plant		Average concentration (pCi/dry g)					6-year-average
	1964	1965	1966	1967	1968	1969	
Antioch	20	12	10	44	8	14	18
El Centro	37	20	15	21	21	30	24
Eureka	28	22	8	1	7	15	14
Fresno	52	15	15	28	17	21	25
Livermore	76	64	54	95	85	214	98
Los Angeles City:							
Hyperion	9	NS	26	22	14	16	17
Los Angeles County	15	15	23	13	7	13	14
East Bay mud	46	20	16	14	8	16	20
Orange County:							
Plant 1	56	29	20	22	5	11	24
Plant 2	35	29	15	31	19	20	25
Pleasanton	460	400	576	320	210	244	370
Sacramento	30	14	14	19	12	15	17
Salinas	30	42	21	NS	16	25	27
San Diego	54	27	18	19	24	21	27
San Francisco:							
Richmond Sunset	62	65	24	26	18	17	35
Southeast	46	30	34	36	28	18	32
San Jose	40	14	25	91	164	200	89
Vallejo	55	23	13	13	10	8	20

NS, no sample.

Radiostrontium in Tap Water, July-December 1970

Health and Safety Laboratory
U.S. Atomic Energy Commission

The Health and Safety Laboratory has performed analyses for strontium-90 in tap water at New York City since August 1954. Samples of tap water are collected daily so that by the end of the month a composite of at least 100 liters is available for analysis. Cesium-137 determinations were begun in January 1964. The analytical methods used at the laboratory are given in the Health and Safety Laboratory Manual of Standard Procedures (*1*).

Strontium-90 concentration and cesium-137 to strontium-90 ratios in New York City tap water for July through December 1970 are presented in table 1. These results appear graphically in figure 1.

A decreasing trend has been observed in the strontium-90 concentrations since the July 1963 peak. The maximum strontium-90 concentrations observed are below the acceptable limit as set forth in the interstate carrier drinking water standards (*2*).

Table 1. Radiostrontium in New York City tap water July-December 1970

Sampling months 1970	Strontium-90[a] (pCi/liter)	$^{137}Cs/^{90}Sr$
July	0.72	0.13
August	.64	.14
September	.64	.13
October	.62	.14
November	.70	.14
December	.68	.11

[a] Approximately 100 liters per sample.

REFERENCES

(*1*) U.S. ATOMIC ENERGY COMMISSION. Manual of standard procedures, 40:E-38-01-16. Health and Safety Laboratory, U.S. Atomic Energy Commission, 376 Hudson Street, New York, N.Y. 10014.

(*2*) FEDERAL REGISTER RULES AND REGULATIONS. Title 42–Public Health, Chapter 1, Public Health Service, Department of Health, Education, and Welfare; Part 72, Interstate Quarantine, Subpart J, Drinking Water Standards 27:2154–2155. Superintendent of Documents, Government Printing Office, Washington, D.C. 20402 (March 6, 1962).

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
January–June 1970	April 1971

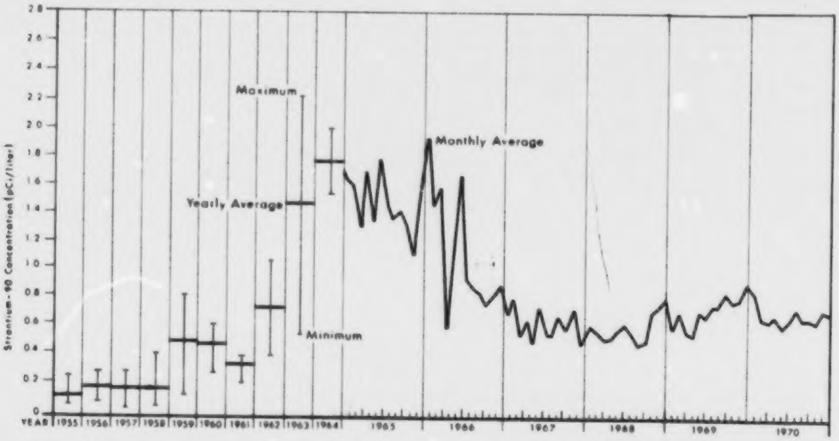

Figure 1. Strontium-90 concentrations in New York City tap water, 1955–December 1970

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[1] Prepared from information appearing in Fallout Program Quarterly Summary Report, HASL 243. This report is available from the National Technical Information Service, 5285 Port Royal Road, Springfield, Va. 22151.

SECTION III. AIR AND DEPOSITION

Radioactivity in Airborne Particulates and Precipitation

Continuous surveillance of radioactivity in air and precipitation provides one of the earliest indications of changes in environmental fission product radioactivity. To date, this surveillance has been confined chiefly to gross beta radioanalysis. Although such data are insufficient to assess total human radiation exposure from fallout, they can be used to determine when to modify monitoring in other phases of the environment.

Surveillance data from a number of programs are published monthly and summarized periodically to show current and long-range trends of atmospheric radioactivity in the Western Hemisphere. These include data from activities of the Environmental Protection Agency, the Canadian Department of National Health and Welfare, the Mexican Commission of Nuclear Energy, and the Pan American Health Organization.

In addition to those programs presented in this issue, the following programs were previously covered in *Radiological Health Data and Reports*.

Network	Period	Issue
Fallout in the United States and other Areas, *HASL*	July–December 1968 and January–December 1969	January 1971
Plutonium in Airborne Particulates and Precipitation	July–December 1970	June 1971
Surface Air Sampling Program, 80th Meridian Network, *HASL*	January–December 1968	April 1971
Mexican Air Monitoring Program	July 1970	November 1970

1. Radiation Alert Network
June 1971

National Environmental Research Laboratory
Environmental Protection Agency

Surveillance of atmospheric radioactivity in the United States is conducted by the Radiation Alert Network (RAN) which regularly gathers samples at 70 locations distributed throughout the country (figure 1). Most of the stations are operated by State Health Department personnel.

The station operators perform "field estimates" on the airborne particulate samples at 5 hours after collection, when most of the radon daughter products have decayed, and at 29 hours after collection, when most of the thoron daughter products have decayed. They also perform field estimates on dried precipitation samples and report all results to appropriate Environmental Protection Agency officials by mail or telephone depending on levels found. A compilation of the daily field estimates is available upon request from the Data Acquisition and Analysis Branch, Division of Air Quality and Emission Data, EPA, Durham, N.C. A detailed description of the sampling and analytical procedures was presented in the March 1968 issue of *Radiological Health Data and Reports.*

Table 1 presents the monthly average gross beta radioactivity in surface air particulates and deposition by precipitation, as measured by the field estimate technique, during June 1971.

All field estimates reported were within normal limits for the reporting station.

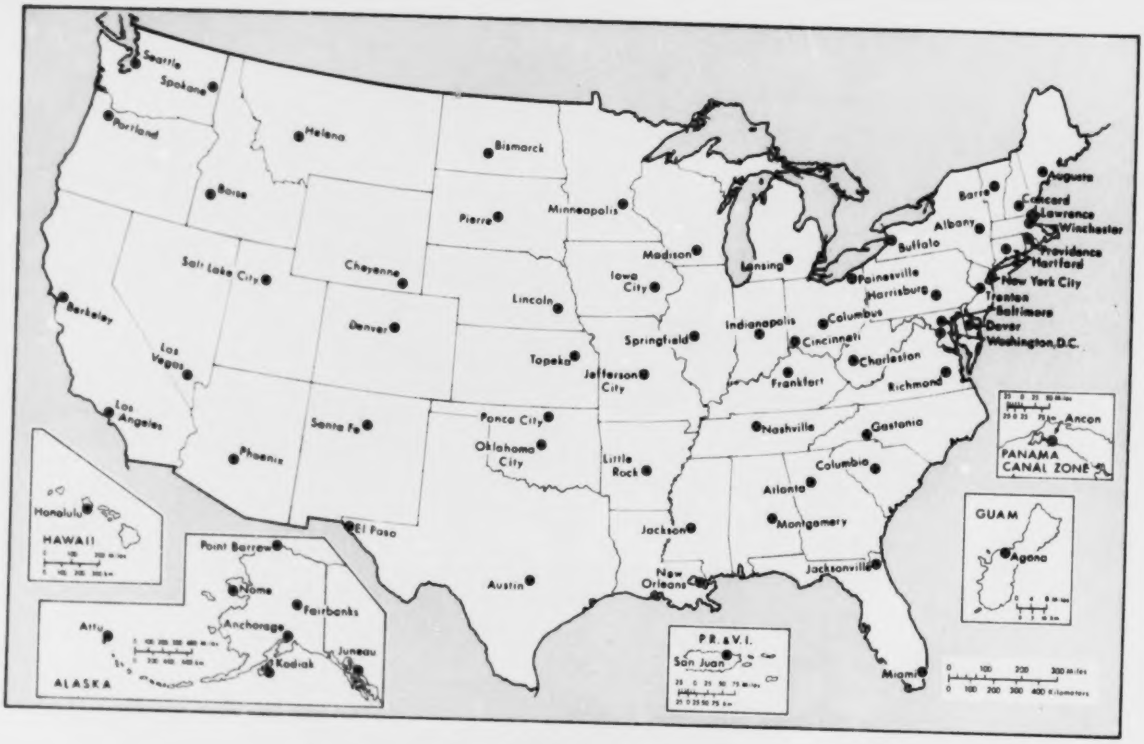
Seattle
Spokane
Portland
Helena
Bismarck
Boise
Pierre
Minneapolis
Augusta
Barre
Concord
Lawrence
Winchester
Albany
Buffalo
Providence
Hartford
Madison
Lansing
Iowa City
Salt Lake City
Cheyenne
Lincoln
Painesville
Harrisburg
New York City
Trenton
Baltimore
Dover
Washington, D.C.
Berkeley
Denver
Indianapolis
Columbus
Springfield
Cincinnati
Topeka
Jefferson City
Charleston
Las Vegas
Frankfort
Richmond
Los Angeles
Ponca City
Oklahoma City
Santa Fe
Nashville
Gastonia
Phoenix
Little Rock
Columbia
Atlanta
Ancon
PANAMA CANAL ZONE
Honolulu
HAWAII
El Paso
Jackson
Montgomery
GUAM
Agana
Point Barrow
Jacksonville
Nome
Fairbanks
Austin
New Orleans
Attu
Anchorage
Kodiak
Juneau
ALASKA
P.R. & V.I.
San Juan
Miami
0 100 200 300 miles
0 100 200 300 400 Kilometers

Figure 1. Radiation Alert Network sampling stations

Table 1. Gross beta radioactivity in surface air and precipitation, June 1971

Station location		Number of samples	Gross beta radioactivity (5-hour field estimate) (pCi/m³)			Number of samples	Total depth (mm)	Precipitation		
								Field estimation of deposition		
			Maximum	Minimum	Average[a]			Number of samples	Depth (mm)	Total deposition (nCi/m²)
Ala:	Montgomery	21	3	1	2	4	479	4	479	68
Alaska:	Anchorage	3	0	0	0	0				
	Attu Island	30	1	0	0	0				
	Fairbanks	5	2	0	1	0				
	Juneau	19	4	0	1	1	4	1	4	2
	Kodiak	4	0	0	0	0				
	Nome	0				0				
	Point Barrow	0				0				
Ariz:	Phoenix	11	6	2	3	0				
Ark:	Little Rock	13	1	0	1	0				
Calif:	Berkeley	21	1	0	0	0				
	Los Angeles	22	2	0	1	0				
C.Z:	Ancon	17	0	0	0	0				
Colo:	Denver	20	5	2	3	2	8	(b)		
Conn:	Hartford	22	1	0	1	5	47	5	47	10
Del:	Dover	22	2	0	1	0				
D.C:	Washington	24	1	0	1	0				
Fla:	Jacksonville	22	2	0	1	9	125	9	125	30
	Miami	21	1	0	0	7	110	7	110	0
Ga:	Atlanta	16	2	1	1	1	15	1	15	26
Guam:	Agana	0				0				
Hawaii:	Honolulu	25	1	0	0	4	69	(b)		
Idaho:	Boise	4	2	1	1	2	5	2	5	1
Ill:	Springfield	0				0				
Ind:	Indianapolis	22	2	0	1	0				
Iowa:	Iowa City	20	5	1	2	3	49	3	49	0
Kans:	Topeka	22	4	1	2	11	98	11	98	3
Ky:	Frankfort	0				0				
La:	New Orleans	19	1	0	1	10	162	(b)		
Maine:	Augusta	22	1	0	1	7	90	7	90	0
Md:	Baltimore	22	2	0	1	5	50	5	50	0
Mass:	Lawrence	22	2	0	1	6	88	6	88	14
	Winchester	21	3	0	1	4	52	4	52	0
Mich:	Lansing	21	2	1	1	6	101	6	101	13
Minn:	Minneapolis	22	3	0	1	5	96	5	96	22
Miss:	Jackson	12	2	0	1	1	16	1	16	5
Mo:	Jefferson City	22	4	1	1	7	96	7	96	1
Mont:	Helena	15	2	0	1	5	40	5	40	0
Nebr:	Lincoln	19	8	1	4	4	41	4	41	17
Nev:	Las Vegas	22	4	1	2	0				
N.H:	Concord	0				0				
N.J:	Trenton	20	2	0	1	7	56	7	56	9
N. Mex:	Santa Fe	20	3	0	1	0				
N.Y:	Albany	22	2	0	1	2	29	2	29	28
	Buffalo	21	2	1	1	0				
	New York City	0				0				
N.C:	Gastonia	16	10	1	4	5	71	(b)		
N. Dak:	Bismarck	21	3	1	1	10	147	10	147	17
Ohio:	Cincinnati	0				0				
	Columbus	4	3	1	1	0				
	Painesville	22	3	1	2	6	123	6	123	305
Okla:	Oklahoma City	3	1	1	1	0				
	Ponca City	20	5	0	1	6	139	6	139	0
Oreg:	Portland	20	1	0	0	9	59	9	59	5
Pa:	Harrisburg	12	3	0	1	0				
P.R:	San Juan	0				0				
R.I:	Providence	21	1	0	1	3	21	3	21	0
S.C:	Columbia	20	3	0	1	4	100	4	100	0
S. Dak:	Pierre	22	1	1	2	0				
Tenn:	Nashville	21	3	0	1	8	98	8	98	17
Tex:	Austin	0				0				
	El Paso	19	3	1	1	0				
Utah:	Salt Lake City	27	3	1	1	2	9	2	9	6
Vt:	Barre	22	5	1	2	6	47	6	47	5
Va:	Richmond	20	2	0	1	4	137	4	137	59
Wash:	Seattle	9	0	0	0	9	53	(b)		
	Spokane	9	1	0	1	0				
W. Va:	Charleston	21	3	0	1	10	98	10	98	14
Wisc:	Madison	21	4	0	1	5	72	5	72	12
Wyo:	Cheyenne	22	9	1	3	1	2	1	2	4
Network summary		1,100	10	0	1	206	91	5	81	20

[a] The monthly average is calculated by weighting the field estimates of individual air samples with length of sampling period.
[b] This station is part of the tritium surveillance system. No gross beta measurements are done.

29

2. Canadian Air and Precipitation Monitoring Program,[1] June 1971

Radiation Protection Division
Department of National Health and Welfare

The Radiation Protection Division of the Canadian Department of National Health and Welfare monitors surface air and precipitation in connection with its Radioactive Fallout Study Program. Twenty-four collection stations are located at airports (figure 3), where the sampling equipment is operated by personnel from the Meteorological Services Branch of the Department of Transport. Detailed discussions of the sampling procedures, methods of analysis, and interpretation of results of the radioactive fallout program are contained in reports of the Department of National Health and Welfare (*1–5*).

A summary of the sampling procedures and methods of analysis was presented in the May 1969 issue of *Radiological Health Data and Reports.*

Surface air and precipitation data for June 1971 are presented in table 2.

Table 2. Canadian gross beta radioactivity in surface air and precipitation, June 1971

Station	Number of samples	Air surveillance gross beta radioactivity (pCi/m³)			Precipitation measurements	
		Maximum	Minimum	Average	Average concentration (pCi/liter)	Total deposition (nCi/m²)
Calgary	24	0.5	0.4	0.5	63	6.03
Coral Harbour	4	.2	.1	.2	355	4.32
Edmonton	17	.5	.4	.4	91	11.88
Ft. Churchill	4	.2	.1	.1	205	10.01
Fredericton	4	.4	.1	.3	180	15.96
Goose Bay	4	.2	.1	.2	66	6.86
Halifax	61	.4	.3	.3	235	13.51
Inuvik	4	.2	.1	.1	169	2.17
Montreal	4	.5	.3	.4	248	11.89
Moosonee	4	.5	.1	.3	39	3.47
Ottawa	4	.5	.4	.4	96	5.22
Quebec	4	.5	.3	.4	253	24.66
Regina	4	1.3	.3	.6	106	8.05
Resolute	4	.2	.0	.1	106	.54
St. John's, Nfld.	4	.6	.2	.4	156	14.63
Saskatoon	4	.4	.3	.4	206	19.05
Sault Ste. Marie	2	.4	.3	.4	196	21.32
Thunder Bay	4	.4	.3	.3	244	17.29
Toronto	4	.5	.2	.3	427	25.21
Vancouver	4	.3	.2	.2	275	17.87
Whitehorse	4	.4	.3	.4	264	13.88
Windsor	4	.4	.3	.3	257	4.49
Winnipeg	4	.5	.4	.4	399	30.23
Yellowknife	4	.2	.1	.1	366	4.55
Network summary	184	1.3	0.0	0.3	208	12.21

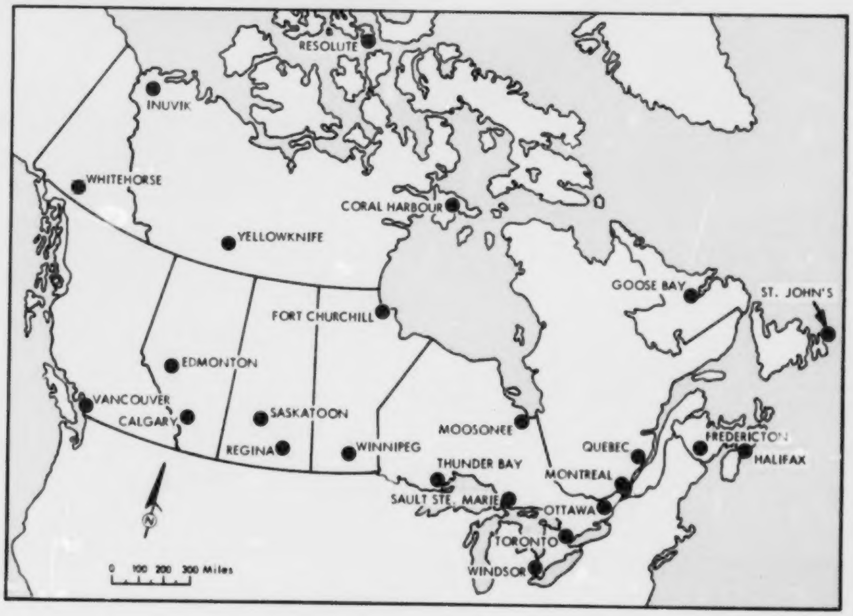
RESOLUTE
INUVIK
WHITEHORSE
CORAL HARBOUR
YELLOWKNIFE
GOOSE BAY
ST. JOHN'S
FORT CHURCHILL
EDMONTON
VANCOUVER
CALGARY
SASKATOON
MOOSONEE
REGINA
WINNIPEG
QUEBEC
FREDERICTON
HALIFAX
THUNDER BAY
MONTREAL
SAULT STE. MARIE
OTTAWA
TORONTO
WINDSOR
N
0 100 200 300 Miles

Figure 2. Canadian air and precipitation sampling stations

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[1] Prepared from information and data obtained from the Canadian Department of National Health and Welfare, Ottawa, Canada.

3. Pan American Air Sampling Program June 1971

Pan American Health Organization and *Environmental Protection Agency*

Gross beta radioactivity in air is monitored by countries in the Americas under the auspices of the collaborative program developed by the Pan American Health Organization (PAHO) and the Environmental Protection Agency (EPA) to assist PAHO-member countries in developing radiological health programs.

The air sampling station locations are shown in figure 3. Analytical techniques were described in the March 1968 issue of *Radiological Health Data and Reports*. The June 1971 air monitoring results from the participating countries are given in table 3. The increased levels of radioactivity are attributed to the recent French nuclear tests in the Pacific.

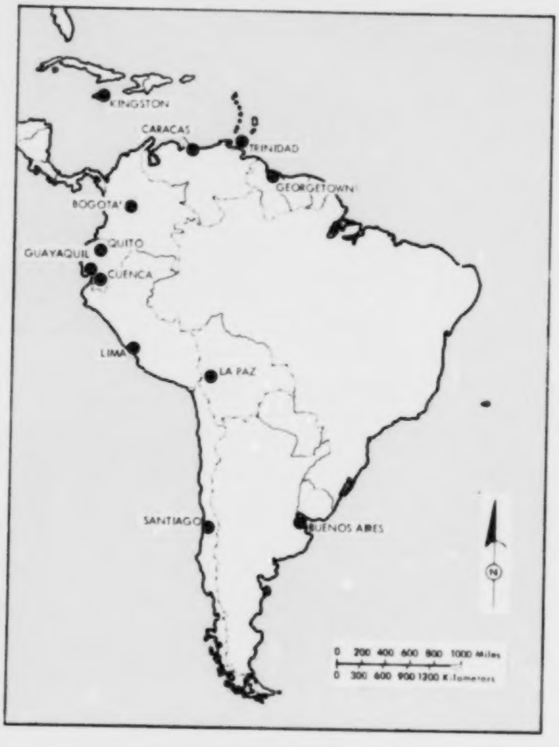

Figure 3. Pan American Air Sampling Program stations

Table 3. Summary of gross beta radioactivity in Pan American surface air, June 1971

Station location	Number of samples	Gross beta radioactivity (pCi/m^3)		
		Maximum	Minimum	Average[a]
Argentina: Buenos Aires	0			
Bolivia: La Paz	0			
Chile: Santiago	29	4.20	0.01	0.83
Colombia: Bogota	9	.16	.01	.06
Ecuador: Cuenca	0			
Guayaquil	20	2.10	.02	.57
Quito	0			
Guyana: Georgetown	0			
Jamaica: Kingston	0			
Peru: Lima	24	2.66	.03	.73
Venezuela: Caracas	4	.40	.13	.36
West Indies: Trinidad	19	.81	.12	.47
Pan American summary	105	4.20	0.01	0.61

[a] The monthly average is calculated by weighting the individual samples with length of sampling period. Values less than 0.005 pCi/m^3 are reported and used in averaging as 0.00 pCi/m^3.

3. Mexican Air Monitoring Program August–December 1970 and January 1971

National Commission of Nuclear Energy
México, D.F.

The Radiation Surveillance Network of Mexico was established by the Comisión Nacional de Energía Nuclear (CNEN), México, D.F. From 1952 to 1961, the network was directed by the Institute of Physics of the University of Mexico, under contract to the CNEN.

In 1961, the CNEN appointed its Division of Radiological Protection to establish a new Radiation Surveillance Network. In 1966, the Division of Radiological Protection was restructured and its name changed to Dirección General de Seguridad Radiológica (DRS). The network consists of 16 stations (figure 4), 11 of which are located at airports and operated by airline personnel. The remaining five stations are located at México, D.F.; Mérida; Veracruz; San Luis Potosí; and Ensenada. Staff members of the DRS operate the station at México, D.F., while the other four sta-

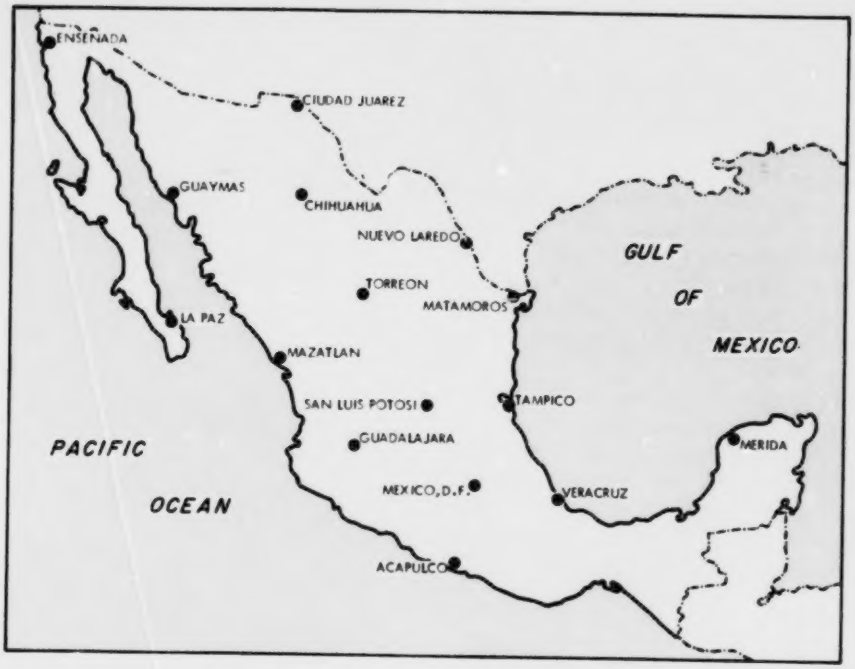
ENSENADA
CIUDAD JUAREZ
GUAYMAS
CHIHUAHUA
NUEVO LAREDO
TORREON
MATAMOROS
GULF
OF
MEXICO
LA PAZ
MAZATLAN
SAN LUIS POTOSI
TAMPICO
GUADALAJARA
MERIDA
PACIFIC
OCEAN
MEXICO, D.F.
VERACRUZ
ACAPULCO

Figure 4. Mexican air sampling locations

Table 4. Mexican gross beta radioactivity of airborne particulates, August 1970

Station location	Number of samples	Gross beta radioactivity (pCi/m^3)		
		Maximum	Minimum	Average
Acapulco	11	0.10	0.03	0.06
Chihuahua	17	.45	.05	.18
Ciudad Juarez	NS			
Ensenada	NS			
Guadalajara	NS			
Guaymas	NS			
La Paz	NS			
Matamoros	NS			
Mazatlan	NS			
Mérida	9	.40	.06	.17
México, D.F	10	.14	.03	.08
Nuevo Laredo	NS			
San Luis Potosí	NS			
Tampico	NS			
Torreón	22	.37	.10	.21
Veracruz	11	.30	.03	.14

NS, no sample, station temporarily shutdown.

Table 5. Mexican gross beta radioactivity of airborne particulates, September 1970

Station location	Number of samples	Gross beta radioactivity (pCi/m^3)		
		Maximum	Minimum	Average
Acapulco	12	0.13	0.03	0.05
Chihuahua	4	.14	.06	.10
Ciudad Juarez	7	.49	.25	.38
Ensenada	NS			
Guadalajara	NS			
Guaymas	NS			
La Paz	NS			
Matamoros	NS			
Mazatlan	NS			
Mérida	NS			
México, D.F	8	.08	.03	.05
Nuevo Laredo	NS			
San Luis Potosí	NS			
Tampico	NS			
Torreón	19	.17	.05	.11
Veracruz	20	.32	.03	.10

NS, no sample, station temporarily shutdown.

tions are manned by members of the Centro de Prevision del Golfo de México, the Chemistry Department of the University of Mérida, the Institute de Zonas Desérticas of the University of San Luis Potosí, and the Escuela Superior de Ciencias Marinas of the University of Baja California, respectively.

Sampling

The sampling procedure involves drawing air through a high-efficiency, 6- by 9-inch glass-fiber filter for 20 hours a day, 3 or 4 days a week at the rate of 1,000 cubic meters per day using high volume samplers.

After each 20-hour sampling period, the filter is removed and shipped via airmail to the Sección de Radioactividad Ambiental, CNEN, in México, D.F., for assay of gross beta radioactivity, allowing a minimum of 3 to 4 days after collection for the decay of radon and thoron daughters. The data are not extrapolated to the time of collection. Statistically, it has been found that a minimum of five samples per month was needed to get a reliable average radioactivity at each station (*6*).

Table 6. Mexican gross beta radioactivity of airborne particulates, October 1970

Station location	Number of samples	Gross beta radioactivity (pCi/m³)		
		Maximum	Minimum	Average
Acapulco	15	0.13	0.03	0.08
Chihuahua	19	.48	.07	.23
Ciudad Juarez	NS			
Ensenada	7	.43	.11	.23
Guadalajara	NS			
Guaymas	NS			
La Paz	NS			
Matamoros	NS			
Mazatlan	NS			
Mérida	3	NA	NA	NA
México, D.F	9	.13	.06	.10
Nuevo Laredo	NS			
San Luis Potosí	NS			
Tampico	NS			
Torreón	17	.39	.08	.21
Veracruz	18	.27	.04	.13

NS, no sample, station temporarily shutdown.
NA, no analysis.

Table 7. Mexican gross beta radioactivity of airborne particulates, November 1970

Station location	Number of samples	Gross beta radioactivity (pCi/m³)		
		Maximum	Minimum	Average
Acapulco	17	0.18	0.05	0.11
Chihuahua	16	.26	.12	.18
Ciudad Juarez	7	.42	.18	.30
Ensenada	2	.19	.15	(a)
Guadalajara	NS			
Guaymas	NS			
La Paz	NS			
Matamoros	NS			
Mazatlan	NS			
Mérida	8	.46	.17	.23
México, D.F	8	.13	.04	.09
Nuevo Laredo	NS			
San Luis Potosí	NS			
Tampico	NS			
Torreón	17	.33	.09	.19
Veracruz	9	.09	.03	.06

[a] Average not calculated.
NS, no sample, station temporarily shutdown.

Table 8. Mexican gross beta radioactivity of airborne particulates, December 1970

Station location	Number of samples	Gross beta radioactivity (pCi/m³)		
		Maximum	Minimum	Average
Acapulco	15	0.24	0.09	0.15
Chihuahua	8	.30	.11	.17
Ciudad Juarez	NS			
Ensenada	4	.32	.12	.22
Guadalajara	NS			
Guaymas	NS			
La Paz	NS			
Matamoros	12	.38	.07	.20
Mazatlan	NS			
Mérida	4	.30	.10	.16
México, D.F	NS			
Nuevo Laredo	1	NA	NA	
San Luis Potosí	NS			
Tampico	15	.47	.06	.19
Torreón	14	.29	.07	.17
Veracruz	NS			

NS, no sample, station temporarily shutdown.
NA, no analysis.

The maximum, minimum, and average beta radioactivity in surface air during August through December 1970 and January 1971 are presented in tables 4 through 9.

Table 9. Mexican gross beta radioactivity of airborne particulates, January 1971

Station location	Number of samples	Gross beta radioactivity (pCi/m³)		
		Maximum	Minimum	Average
Acapulco	17	0.31	0.10	0.18
Chihuahua	7	.92	.07	.37
Ciudad Juarez	NS			
Ensenada	NS			
Guadalajara	NS			
Guaymas	NS			
La Paz	NS			
Matamoros	2	.13	.12	(a)
Mazatlan	NS			
Mérida	10	.54	.08	.25
México, D.F.	12	.15	.06	.10
Nuevo Laredo	NS			
San Luis Potosi	NS			
Tampico	15	.22	.06	.14
Torreón	8	.47	.13	.25
Veracruz	3	.17	.16	(a)

[a] Average not calculated.
NS, no sample, station temporarily shutdown.

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(2) BIRD, P. M., A. H. BOOTH, and P. G. MAR. Annual report for 1960 on the Radioactive Fallout Study Program, CNHW-RP-4. Department of National Health and Welfare, Ottawa, Canada (December 1961).

(3) MAR, P. G. Annual report for 1961 on the Radioactive Fallout Study Program, CNHW-RP-5. Department of National Health and Welfare, Ottawa, Canada (December 1962).

(4) BEALE, J. and J. GORDON. The operation of the Radiation Protection Division Air Monitoring Program, RPD-11. Department of National Health and Welfare, Ottawa, Canada (July 1962).

(5) BOOTH, A. H. The calculation of permissible levels of fallout in air and water and their use in assessing the significance of 1961 levels in Canada, RPD-21. Department of National Health and Welfare, Ottawa, Canada (August 1962).

(6) VASQUEZ, M. and R. M. DE NULMAN. Estudios sobre la radioactividad ambiental en la Republica Mexicana, 1963-1965. Comision Nacional de Energia Nuclear, Direccion General de Seguridad Radiologica (1966).

SECTION IV. OTHER DATA

This section presents results from routine sampling of biological materials and other media not reported in the previous sections. Included here are such data as those obtained from human bone sampling, Alaskan surveillance, and environmental monitoring around nuclear facilities.

Environmental Levels of Radioactivity at Atomic Energy Commission Installations

The U.S. Atomic Energy Commission (AEC) receives from its contractors semiannual reports on the environmental levels of radioactivity in the vicinity of major Commission installations. The reports include data from routine monitoring programs where operations are of such a nature that plant environmental surveys are required.

Releases of radioactive materials from AEC installations are governed by radiation standards set forth by AEC's Division of Operational Safety in directives published in the "AEC Manual."[1]

A summary of the environmental radioactivity data follows for the Lawrence Radiation Laboratory.

1. Lawrence Radiation Laboratory[2] July–December 1970

University of California
Berkeley, Calif.

Berkeley site

The Berkeley site of the Lawrence Radiation Laboratory (LRL) is situated on the western slope of the range of hills running along the eastern side of San Francisco Bay. The laboratory area is largely separate from the main campus of the University (figure 1).

To the north and south of the laboratory area are residential areas of the cities of Berkeley and Oakland. The Berkeley campus of the University of California is on the west; to the east, are the Lawrence Hall of Science and the Space Sciences Laboratory, beyond them lies uninhabited watershed land and the Tilden Regional Park.

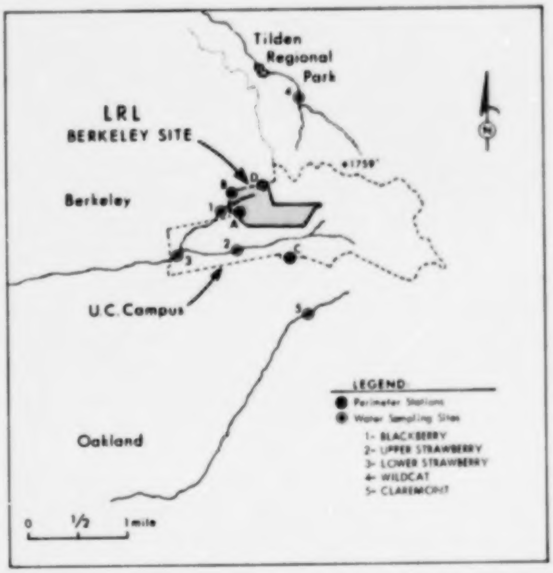

Figure 1. Environmental sampling locations at the Berkeley site, Lawrence Radiation Laboratory

The most prevalent wind direction is westerly. During the summer months, the afternoon sea breeze establishes a very pronounced prevailing westerly wind direction. At other times, the direction is less predictable. Annual rainfall is 23 inches, almost all of which falls between November

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[1] Title 10, Code of Federal Regulations, Part 20, "Standards for Protection Against Radiation" contains essentially the standards published in Chapter 0524 of the AEC Manual.

[2] Summarized from "Results of Environmental Radioactivity Sampling Program, July–December 1970," Lawrence Radiation Laboratory, Livermore and Berkeley, Calif. 94720.

1 and May 1. The prevailing wind direction during precipitation is southerly.

The laboratory carries on a wide ranging program of general research in the fields of both physical and biological sciences. Facilities include a number of large accelerators, and various physics, chemistry, biology, and medical research laboratories.

The basic policy at LRL has long been to prevent, as far as possible, any release of radioactive material to the environment, no matter how small. No deliberate releases are sanctioned, except where no practical method for containment has yet been developed, and quantities are small compared with standards established by the International Commission on Radiological Protection (ICRP) and the Atomic Energy Commission (AEC).

The most sensitive measurements of releases are those taken closest to the source itself, before dilution makes detection of small quantities more difficult. The stack sampling program, therefore, provides the most useful information for controlling releases to the atmosphere. Over 100 separate exhausts from hoods and glove-box manifolds are sampled. The total quantity released from these stacks during July–December 1970 was 300 nCi of alpha radioactivity, 420 mCi of carbon-14, 18.3 curies of tritium and 53 μCi of other beta-particle emitters. The average concentrations in the total exhaust, before any dilution by the atmosphere, was 25 percent of the maximum permissible concentrations for offsite breathing zone air, as given by the ICRP.

In addition to the careful sampling of stacks, an environmental air sampling program is also carried on to make sure no undetected releases occur. These samples provide a direct measurement of possible exposure to the nearby population. The sampling stations designated "local area" are scattered around the site and provide samples of the atmosphere on the site itself. The "perimeter" samples are taken at the boundary line of University property, in the direction of populated areas. From the results of these samples, there appears to have been no significant exposure from radioactive materials released by LRL. The levels of radioactivity observed in each type of sample are presented in table 1.

At each of these environmental stations, rain or dry fallout is also collected. Open 15-inch-diameter polyethylene bags form the collecting vessel. If no rain has fallen, the bags are rinsed out with water to obtain a sample. Since on the average, the more remote perimeter stations show about the same radioactivity as the nearer ones, the radioactivity does not result from laboratory operations. The radioactivity levels in samples collected at each location are summarized in table 2.

Table 1. Atmospheric monitoring, LRL Berkeley site July–December 1970

Sampling locations (number of locations)	Number of samples	Average concentration (pCi/m³)			
		Alpha radioactivity		Beta radioactivity	
		Average	Maximum	Average	Maximum
Local area (10)	258	0.000	<0.005	0.16	0.50
Perimeter					
A	26	.000	.005	.15	.48
B	23	.000	< .005	.16	.40
C	26	.000	< .005	.16	.44
D	24	.000	< .005	.19	.41
Summary	99	.000	< .005	.16	.48

Table 2. Total deposition, LRL Berkeley site July–December 1970

Sampling locations (number of locations)	Number of samples	Average deposition (nCi/m²)			
		Alpha radioactivity		Beta radioactivity	
		Average	Maximum	Average	Maximum
Local area (10)	54	0.008	0.046	2.99	4.01
Perimeter (4)	24	.000	.019	3.73	4.86

All liquid waste known to be radioactive is collected, solidified, and shipped away. Other liquid wastes are discharged directly to the municipal sewer system. Occasionally, small quantities of radioisotopes are accidentally released to the sewer system. There are two outfalls, each of which is monitored by a continuous proportional sampling system to insure that no significant quantities have been discharged (table 3). The total concentration (alpha-plus-beta radioactivity) in sewage is only 31 percent of the standard for drinking water and therefore does not constitute an exposure threat.

The storm drainage from the laboratory flows into the surface stream system. These surface streams are exposed as they run through the University property and are sampled at three places.

Table 3. Summary of sewer data, LRL Berkeley site, July–December 1970

Sewer	Total quantities discharged 6 months			Net concentrations (pCi/liter)				
	Total volume (Ml)	Total alpha radioactivity (μCi)	Total beta radioactivity (mCi)	Number of samples	Alpha		Beta	
					Average	Maximum	Average	Maximum
Hearst	119.3	11.3	4.30	24	0.09	3.2	36.1	185
Strawberry	38.4	2.4	.49	24	.06	1.8	12.7	25
Summary	157.7	13.7	4.79		0.09		30.3	

Results are listed as "onsite streams" in table 4. Two nearby offsite streams are also sampled to provide a comparison. All concentrations are less than the standard for drinking water. The results from the water sampling program are presented in table 4.

Table 4. Water monitoring, LRL Berkeley site July–December 1970

Type and source of sample	Number of samples	Concentration (pCi/liter)			
		Alpha radioactivity		Beta radioactivity	
		Average	Maximum	Average	Maximum
Surface water:					
Onsite streams					
Blackberry	26	0.30	1.2	3.27	14.3
Lower Strawberry	26	.33	8.5	7.37	29.3
Upper Strawberry	26	.14	1.6	2.95	9.3
Summary		0.26	8.5	4.53	29.3
Offsite streams:					
Claremont	26	.68	2.9	3.00	13.3
Wildcat	26	.16	1.7	2.19	5.0
Summary		0.42	2.9	2.60	13.3
Tap water	24	.005	.37	1.35	3.2

Neutron and gamma-ray fields are measured at each of the four perimeter stations as well as at several locations within the site. Background measurements are obtained from a leased building used as a low-level counting room in downtown Berkeley. This building is remote from the main LRL site and measurements are not influenced by accelerator operations.

At each station, gamma measurements are made by a recording G-M detector, standardized with a calibrated radium source. These instruments operate unattended and each can operate for 1 week on its internal battery should external power fail.

Several neutron detectors are employed at each station. The primary detector is a BF_3 gas proportional counter in a $2\frac{1}{2}$ inch-thick paraffin-lined moderator. This detector is sensitive in the region from 0.1 to 20 MeV, where 75 percent of the biologically significant neutrons exist. A polyethylene-lined proton recoil neutron detector provides a measure of the energy flux density. The ratio of energy flux density to neutron flux density gives the average neutron energy which allows conversion of the data to dose in rems. Cobalt disks in moderators are maintained as long term integrating neutron monitors at many sites throughout the laboratory as well as at each perimeter station.

Cosmic ray intensity is continuously monitored by a meson detector with an effective angle of acceptance of 2.3 steradians (in the upward direction). This provides information on the background neutron levels contributed by cosmic rays.

At each station, total radiation levels are well below the standards set for the general public by the ICRP and National Council on Radiation Protection and Measurements (NCRP). Results are presented in table 5.

Table 5. Beta-gamma and fast neutron surveillance results, Berkeley site, July–December 1970

Station	Total beta-gamma exposure (mrem) (background subtracted)	Total fast neutron exposure[a] (mrem) (background subtracted)
A	11.9	54.5
B	16.0	28.4
C	Background	Background
D	3.0	22.5
Downtown Berkeley	(b)	(b)

[a] 2.45×10^7 n/cm² = 1 rem.
[b] Detector not in service.

Livermore site

The Livermore site of LRL (figure 2) is located in the Livermore Valley midway between the Pacific coast and the San Joaquin Valley in

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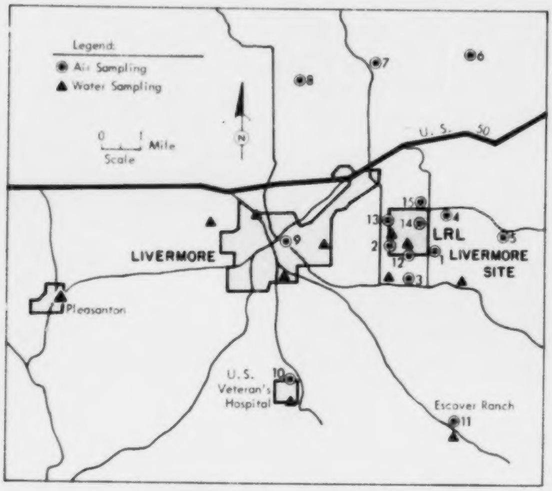

Figure 2. Environmental sampling locations at the Livermore site, Lawrence Radiation Laboratory

northern California, approximately 50 miles southeast of San Francisco. Shielded from the ocean by the western hills, the Livermore Valley has a warm, dry climate. Annual rainfall is about 14 inches with most of the precipitation occurring during the winter months. Prevailing winds are from the west, but inversions are frequent during the night.

Agriculture is the principal activity in the Livermore Valley. Roses, grain, hay, and grapes are the major products. Several cattle and sheep ranches surround the Livermore site.

The Livermore site comprises an area of 1-square mile, approximately 3 miles east of the city of Livermore. Livermore and Pleasanton, with a combined population of 45,000 are populated areas of primary interest to the Livermore site.

An environmental sampling program is maintained to provide information regarding the effectiveness of control measures and to determine whether any radiological changes in the environment are the result of laboratory operations. The sampling program includes air particulates, soil, domestic water, sewer effluent, sewage plant products, milk, and vegetation. The milk samples are obtained from one dairy in the Livermore Valley and from another dairy near Site 300.

Techniques

The LRL Environmental Program is currently undergoing a significant upgrading. This upgrading will greatly improve the analytical sensitivities in order to determine actual background levels of specific radionuclides in the environment. During the transition period, the program will consist of two parts, (1) the gross radioactivity measurements similar to those made in the past, and (2) the special measurements designed to measure the activity of specific radionuclides in environmental samples at background levels.

The analytical techniques used in the above measurements are provided below:

1. Gross radioactivity measurements:

An automated counting system is used for all environmental air samples. This system utilizes gas-flow proportional detectors for both alpha- and beta-particle counting. The alpha-particle detector is approximately 20 percent efficient for the 5.1 MeV alpha of plutonium-239. The efficiency for the 0.54 MeV and 2.27 MeV betas of strontium-90 in equilibrium with yttrium-90 is about 28 percent.

Soil, water, and sewage samples are counted on an automatic low-background system that detects alpha particles with an efficiency of about 34 percent at 5.1 MeV and strontium-yttrium-90 beta particles with an efficiency of approximately 50 percent.

The milk samples are concentrated using a vacuum-operated, foam-entrainment evaporator so that about 9 liters of whole milk are condensed to 2 liters by evaporation. The sample is counted in a plexiglass container placed between two 8- by 4-inch NaI(Tl) crystals. The data are recorded in a multichannel analyzer and processed by a computer code using standard spectra taken on the same counting apparatus.

The vegetation samples taken from nine locations throughout the Livermore Valley are dried in ambient air for about 1 week. Then 150–200 grams of dry material are pressed into a pellet 5 inches in diameter by $\frac{1}{2}$ to 1 inch thick. The pellet is then counted on the system described for milk. The data are also processed by computer.

Samples of environmental water, milk, and vegetation are analyzed for tritium. One milliliter of water or distillate is counted in a liquid scintillation counter having a 32 percent efficiency for HTO.

The soil samples are prepared by digesting 1 gram of material in a mixture of perchloric and nitric acids and evaporating to near dryness. The resulting residue is redissolved in a hydrogen peroxide and nitric acid mixture and subsequently plated onto stainless-steel plates. The water and sewage samples, of ½ liter volume, are treated similarly.

2. Special measurements:

Soil samples are subjected to either a complete acid dissolution or the HASL[3] leach technique for plutonium-239 and strontium-90 determinations. A minimum of 100 grams of soil is used for these analyses. The cesium-137 activities in soil samples are determined directly by placing approximately 300 grams of soil on GeLi detector equipped with background and Compton suppression systems.

The water samples that are analyzed for tritium activity are pretreated by vacuum distillation under an argon atmosphere, enriched 75 fold electrolytically and counted by a liquid scintillation detector.

The air and water samples are subjected to gross alpha and gross beta measurements. Even though the analyses of these samples indicate that iodine-129, actinium-227, radium-226, and radium-228 are not present, the average gross alpha activities still may not exceed the AEC standards for air and water for controlled and uncontrolled areas. Since the alpha emitters have already been accounted for in the gross alpha measurements, the average gross beta radioactivity of the samples may not exceed the AEC standards for air and water for controlled and uncontrolled areas. The AEC Manual Chapter 0524 also states that the average tritium activities in offsite water samples may not exceed 3 μCi/liter.

The average monthly alpha and beta radioactivity of sewage effluent samples should not exceed the guide value of 400 pCi/liter (AEC standard for water in a controlled area), and the tritium activity should not exceed 10^8 pCi/liter.

The annual external radiation dose to the whole body of workers in controlled areas may not exceed 5 rem; while that to individuals in uncontrolled areas may not exceed 170 mrem.

Air and soil samples are collected to ascertain that control efforts are restricting the release of radioactivity from the laboratory to levels that do not exceed the permissible levels for the neighborhood around an atomic energy facility. The water samples are collected to ascertain that radioactivity is not entering the underground water supply which provides most of the domestic water for the cities of Livermore and Pleasanton, the sole supply for ranches in the Livermore and Amador Valleys. Samples were taken at the Livermore Sewage Disposal Plant to establish that liquid effluent from the laboratory is not contributing significant radioactivity to the dried sludge or liquid effluent produced. The dried sludge is used as an agricultural soil conditioner. Some liquid effluent released to the Los Positas Arroyo is used for irrigation of the golf course turf and some agricultural land.

Air particulate samples were collected continuously at 15 sampling stations. The samplers situated on the laboratory perimeter utilize 80 square inch Whatman filters at an average flow rate of 25 cfm. The remaining samplers utilize 36 square inch HV-70 filters at an average flow of 4 cfm. Filters are changed weekly during the winter months and biweekly during the summer to avoid excessive mass loading. The results are shown in table 6.

At no time was any detectable alpha radioactivity observed on the air filters. The average airborne beta radioactivity was 0.1 pCi/m^3; about the same as that reported during the previous 6 months.

Soil samples were collected quarterly. Only the top 1 cm layer was collected at the 19 sampling locations in the Livermore Valley. The alpha radioactivity of each sample was less than the limit of detection (1.5 pCi/g). The beta radioactivities fluctuated from 4.7 pCi/g to 15 pCi/g with an average of 7.5 pCi/g. The limit of detection is 3.5 pCi/g. The radioactivity detected is within the normal range for soil in the Livermore Valley, as determined from surveillance during previous years.

Additional soil samples were collected onsite and offsite within a 4-square-mile area immediately east of the Livermore Laboratory. These samples were subjected to plutonium-239, strontium-90 or cesium-137 determinations. The first seven samples shown in table 7 were analyzed by complete acid dissolution of the soil while the remaining samples were subjected to the HASL acid leach technique

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[3] HASL–Health and Safety Laboratory, U.S. Atomic Energy Commission.

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Table 6. Airborne particulate radioactivity around LRL Livermore site July–December 1970

Sampling location	Number of samples	Alpha radioactivity[a] (fCi/m³)		Beta radioactivity[a] (fCi/m³)	
		Average	Maximum	Average	Maximum
1	46	≤0.4	≤0.4	107	210
2	49	≤ .4	≤ .4	98	230
3	26	≤1.0	≤1.0	72	144
4	24	≤1.0	≤1.0	[illegible]	204
5	25	≤1.0	≤1.0	[illegible]	191
6[b]	NS				
7	26	≤1.0	≤1.0	64	142
8	26	≤1.0	≤1.0	69	205
9	22	≤1.0	≤1.0	119	330
10	23	≤1.0	≤1.0	66	130
11	25	≤1.0	≤1.0	53	99
12	49	≤ .4	≤ .4	121	248
13	49	≤ .4	≤ .4	109	264
14	49	≤ .4	≤ .4	152	420
15	48	≤ .4	≤ .4	130	319
16	26	≤1.0	≤1.0	93	213

[a] Approximate limits of sensitivity: Alpha—locations 1, 2, 12-15—4 fCi/m³.
locations 3-11, 16—1.0 fCi/m³.
Beta—locations 1, 2, 12-15—4 fCi/m³.
locations 3-11, 16—10 fCi/m³.
Estimated counting error limits: alpha radioactivity ±30 percent; beta radioactivity ±20 percent.

[b] Sampler is being relocated.

Table 7. Radioactivity in soil samples, July–December 1970

Location	Depth (inches)	Average concentration (dpm/g)		
		Plutonium-239	Cesium-137	Strontium-90
Onsite[a]	0-2	$2.4\times10^{-2}\pm5\%$	0.86 ± 6%	—
	2-4	$1.8\times10^{-2}\pm6\%$	.69 ±13%	—
	4-6	$2.3\times10^{-3}\pm13\%$	.20 ±25%	—
Off-site	0-2	$2.8\times10^{-3}\pm16\%$	.38 ±21%	—
	2-4	$1.8\times10^{-3}\pm26\%$	.44 ±25%	—
	4-6	$3.7\times10^{-4}\pm20\%$	.15 ±53%	—
Offsite	0-2	$3.8\times10^{-3}\pm19\%$	.22 ±36%	—
Offsite	0-6	$9.0\times10^{-4}\pm9\%$	≤ .03	0.099 ±11%
	0-6	$1.2\times10^{-3}\pm10\%$	≤ .03	.061 ±18%
	0-6	$3.9\times10^{-3}\pm5\%$	.081 ±22%	.077 ± 7%
	0-6	$2.8\times10^{-3}\pm6\%$	.063 ±27%	.082 ± 7%
	0-6	$2.5\times10^{-3}\pm6\%$	.050 ±32%	.055 ±14%
	0-6	$8.6\times10^{-4}\pm11\%$	≤ .03	.045 ±14%

[a] Adjacent to area used for solar evaporation of radioactive liquids.

for plutonium-239 determination. Each sample was collected over a 10 square-inch surface area.

Domestic water samples were collected monthly from 10 nearby sources. No sample showed an alpha radioactivity above the limit of detection (1.2 pCi/liter). The gross beta radioactivities are shown in table 8.

The limit of detection for gross beta radioactivity is 2.5 pCi/liter. The tritium activity of the water samples fluctuated from below the limit of detection (3.5 nCi/liter) to 5.4 nCi/liter. The average tritium activity was ≤3.6 nCi/liter. Several water samples were collected weekly

Table 8. Beta radioactivity in domestic water supplies LRL Livermore site, July–December 1970

Dosimeter location	Beta radioactivity[a] (pCi/liter)	
	Maximum	Average
1	3.4	3.4
3	7.7	2.8
4	5.9	≤2.5
5	4.1	≤2.5
6	3.2	≤2.5
7	14	4.1
8	5.5	≤2.5
10	4.5	≤2.5
Building 253	≤2.5	≤2.5
Building 419	≤2.5	≤2.5

[a] The limit of detection for gross beta radioactivity is 2.5 pCi/liter.

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during the months of July, August, and September from the city of Livermore and Site 300 wells, as well as other miscellaneous sources of drinking water in the immediate vicinity of the laboratory. The weekly samples collected at a particular source were composited into a single sample from that source. Tritium results are shown in table 9.

Samples were collected daily at the laboratory sewer discharge. A portion of each of these daily samples were composited during each month. These monthly composite samples for the radionuclides analyzed are shown in table 10.

When the sewage from the laboratory and city of Livermore enters the sewage disposal plant, the liquid and sludge are separated, and the sludge passes into one of two digesters where it is broken down by bacterial action. Methane gas is evolved and burned and the remaining sludge is released to large, sludge lagoons and/or drying beds and

Table 9. Tritium radioactivity in water LRL Livermore, July–December 1970

Livermore		Site 300	
Well number	Tritium (pCi/liter)	Well number	Tritium (pCi/liter)
8	19 ± 19	1	14 ± 14
9	22 ± 10	3	≤ 14
10	25 ± 18	4	≤ 20
13	75 ± 15	5	23 ± 14
14	72 ± 13	6	50 ± 18
15	17 ± 14	7	≤ 13
17	39 ± 12	8	≤ 20
19	74 ± 15		
20	80 ± 17		

Table 10. Radioactivity in laboratory sewer effluent samples July–December 1970

Month (1970)	Alpha radioactivity (pCi/liter)		Beta radioactivity (pCi/liter)		Tritium (nCi/liter)		Strontium-90 (pCi/liter)	Radium-226 (fCi/liter)	Radium-228 (pCi/liter)	Mixed iodine (pCi/liter)
	Maximum	Average	Maximum	Average	Maximum	Average				
July	24	8.0	1,040	157	500	22	5.1	34	0.36	0.34
August	18	4.0	1,724	387	68	6	22	120	1.1	3.8
September	9	≤1.2	213	102	21	4.6	4.9	45	.37	60
October	1.2	≤1.2	210	75	14	4.7	4.0	18	.35	25
November	19	4.0	285	105	24	7.5	7.4	150	1.7	11
December	19	7.0	373	77	82	25	4.5	35	.39	9.1

Table 11. Radioactivity in samples from the Livermore sewage disposal plant, July–December 1970

Radioactivity, units of measurement and location of sampling	1970					
	July	August	September	October	November	December
Gross alpha (pCi/liter)						
Digesters:						
Maximum	452	455	321	508	220	338
Average	306	290	254	276	144	214
Aeration tank:						
Maximum	201	120	150	33	41	86
Average	163	107	64	21	27	42
Effluent:						
Maximum	≤1.2	≤1.2	≤1.2	≤1.2	≤1.2	≤1.2
Average	≤1.2	≤1.2	≤1.2	≤1.2	≤1.2	≤1.2
Gross beta (pCi/liter)						
Digesters:						
Maximum	2,000	5,500	1,200	1,300	6,200	1,800
Average	1,300	1,700	830	800	500	750
Aeration tank:						
Maximum	325	329	417	84	70	103
Average	281	213	206	67	55	58
Effluent:						
Maximum	45	130	45	28	25	32
Average	28	46	19	13	8	13
Tritium (nCi/liter)						
Aeration tank:						
Maximum	4.0	5.0	≤3.5	≤3.5	≤3.5	33
Average	≤3.6	≤3.9	≤3.5	≤3.5	≤3.5	≤9.7
Effluent:						
Maximum	29	7.0	≤3.5	4.0	≤3.5	12
Average	≤6.6	≤3.9	≤3.5	≤3.5	≤3.5	≤5.8
Strontium-90 (pCi/liter)						
Effluent:						
Average	NA	NA	≤ .4	≤ .4	1.0	.5

NA, no analysis.

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retained for subsequent possible use as a soil conditioner. The purified water is used on the Livermore golf course and agricultural irrigation on a nearby farm; the excess is discharged into the Los Positas Arroyo. Samples were collected weekly from the aeration tanks, each digester, and the effluent to the arroyo. The results of these analyses are given in table 11. The limits of detection are 1.2 pCi/liter for the gross alpha radioactivity, 2.5 pCi/liter for the gross beta measurements, 3.5 nCi/liter for the tritium determinations, and 0.4 pCi/liter for strontium-90.

Samples were collected monthly from each of two dairies in the Livermore Laboratory and Site 300 areas. The average radioactivity in the milk samples is shown in table 12.

Table 12. Radionuclides in milk, LRL July–December 1970

Location of dairy	Concentration (pCi/liter)		
	Cesium-137	Cerium-144	Tritium
3 miles north of Site 300	≤1.9	≤3.5	≤3,500
6 miles west of Livermore Laboratory	2.7	≤5.5	≤3,500

Samples of vegetation were collected during July and October of 1970; the radioactivity per unit dry weight of unwashed grass samples and eucalyptus leaf samples is shown in table 13. A portion of each sample was freeze dried and the water collected was analyzed for HTO.

Continuous air sampling is maintained on the stack effluent from operations that are potential sources of radioactive material releases. These facilities include hot cells, transuranic chemistry, plutonium metallurgy, and the reactor building. The effluent from these buildings passes through high-efficiency filters prior to being exhausted to the atmosphere. The offsite concentrations were not exceeded as a result of the stack effluent from these facilities.

The measurement of low-level gamma radiation was accomplished with thermoluminescent dosimeters at nine points on the site perimeter and at three offsite locations. The dose received by each detector during the 6-month period is shown in table 14. The limit of detection of these dosimeters is 10 mR.

Accidential release of tritium gas

Continuous air sampling is also maintained on the stack effluent from the gaseous chemistry Building. On August 6, 1970, an accidental release of tritium gas occurred from this facility. During the following 4 days, an extensive environmental sampling program was conducted to evaluate the effects of the release on the environment. The vast amount of environmental data that was obtained is too voluminous to report here and will be reported shortly in a separate publication.

The limits of detection for tritium is 5 nCi/liter of water and 40 pCi/m^3 of air. The data indicate that no significant exposure to onsite or offsite individuals resulted from the release. Detectable activities were observed in some vegetation and atmospheric water vapor samples. However, even the highest measured concentrations, as well as the

Table 13. Radioactivity in vegetation, LRL Livermore site, July–December 1970

Nuclide	Concentration (pCi/g dry weight)				Limit of detection
	Grass		Eucalyptus leaves		
	Average	Maximum	Average	Maximum	
Beryllium-7	1.1	3.1	0.58	1.2	0.01
Manganese-54	.18	1.1	≤ .01	≤ .01	.01
Zirconium-95	.49	1.6	.16	.37	.01
Ruthenium-103	≤ .02	.04	≤ .02	.04	.02
Ruthenium-106	.56	2.7	.31	.96	.02
Antimony-125	≤ .02	.03	≤ .02	.09	.02
Cesium-137	.04	.12	.06	.13	.01
Barium-140	.52	1.9	.07	.11	.01
Cerium-144	1.5	4.1	.64	1.3	.02
Tritium (nCi/liter)	14	22	5.8	17	3.5

Table 14. External gamma radiation measurements LRL Livermore site, July–December 1970

Dosimeter locations[a]	Exposure[b] (mR)
1	17
2	≤ 10
3	≤ 10
4	≤ 10
5	70
6	≤ 10
7	17
8	14
9	15
10	≤ 10
11	≤ 10
12	≤ 10

[a] Locations 1–9, controlled area perimeter. Locations 10, 11, and 12, uncontrolled area.
[b] Minus backgroud.

calculated maximum credible ground level air concentration, that could have resulted during cloud passage were well below the offsite maximum permissible concentration for continuous exposure.

Site 300

The high explosive test area at Site 300 (figure 3) covers 10-square miles in the hills, in a very sparsely populated ranching area about 15 miles southeast of Livermore and 8 miles southwest of Tracy. The chief area of concern for Site 300 is Tracy with a population of about 15,000. Air and water samples are taken to determine whether operations at Site 300 are changing the normal radioactivity levels in the vicinity. The 11 air samplers at Site 300 are operated on a continuous basis at about 25 cfm and the filter papers are changed weekly. Most of these air samplers are located within the boundaries of the test site due to unavailability of electric power facilities offsite. Table 15 gives the airborne particulate radioactivity for July–December 1970. Water samples are collected monthly from onsite wells. Streams in the area are sampled when they contain water (usually during the winter). No sample showed an alpha radioactivity concentration above the limit of detection (1.2 pCi/liter). The average beta concentrations are given in table 16. The tritium activities of the water samples fluctuated from below the limits of detection (3.5×10^3 pCi/liter) to a high of 8.6×10^3 pCi/liter. The average tritium activity was $\leq 3.8 \times 10^3$ pCi/liter.

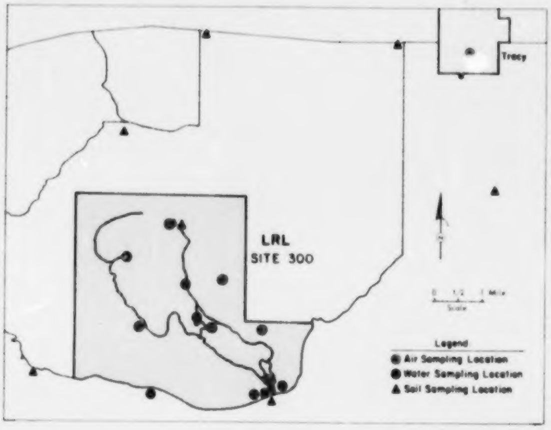

Figure 3. Sampling location at Site 300, LRL

Table 15. Airborne particulate radioactivity, LRL Site 300, July–December 1970

Sampling location	Number of samples	Alpha radioactivity[a] (fCi/m³)		Beta radioactivity[a] (fCi/m³)	
		Average	Maximum	Average	Maximum
1[b]	34	<0.2	0.2	161	378
2	31	< .2	1.0	210	418
3	35	< .2	1.0	181	472
4	30	< .2	< .2	192	386
5	34	< .2	6.6	136	304
6[b]	10	< .2	< .2	132	212
7	34	<1.0	<1.0	148	332
8	33	< .2	< .2	164	430
9	34	< .2	1.1	233	521
10	23	< .2	1.0	180	399
11	33	< .2	< .2	147	372
Summary	331	<0.2	6.6	171	521

[a] Limit of detection: alpha radioactivity, location 1–6, 8–11, 0.2 fCi/m³; location 7, 1.0 fCi/m³; beta radioactivity, location 1–6, 8–11, 2 fCi/m³; location 7, 10 fCi/m³.
Variations in limits of detection results from differing flow rates. Estimated counting error limits, alpha radioactivity ±30 percent; beta radioactivity ±20 percent.
[b] Sampler inoperative for several weeks.

Table 16. Beta radioactivity in water samples, LRL Site 300, July–December 1970

Sampling location	Beta radioactivity (pCi/liter)	
	Maximum	Average
1	3.6	2.6
2	6.8	4.7
3	9.5	6.9
4	8.6	4.9
5	10.9	5.7
6	6.4	3.4
7	6.8	5.2
11	10.9	7.9
14	7.7	6.2

Soil samples were collected quarterly at nine offsite locations. The alpha radioactivity was below the limit of detection (1.5 pCi/g). The beta radioactivity ranged from the limit of detection (3.5 pCi/g) to 15 pCi/g, with an average activity of 5.9 pCi/g.

None of the average concentrations of air, water, and soil samples exceeded the concentration guide levels of environmental radioactivity, nor did any of the results increase significantly compared to the previous 6-month reporting period. Therefore, it appears that radiological control measures at Site 300 were adequate and that no significant radioactivity was released to the environment near the site during this period.

Recent coverage in *Radiological Health Data and Reports*:

Period	Issue
July–December 1969	November 1970
January–June 1970	May 1971

Reported Nuclear Detonations, September 1971

(Includes seismic signals presumably from foreign nuclear detonations)

Seismic signals from a Soviet underground nuclear explosion in the range of 2 to 4 megatons were recorded by the United States. The signals originated at approximately 2:00 a.m., EDT, September 27, 1971, at the Novaya Zemlya nuclear test area in the Arctic.

The signals from this test were almost as large as those of the 3 to 6 megaton test conducted at Novaya Zemlya by the U.S.S.R. last year on October 14.

The U.S Atomic Energy Commission announced only one underground nuclear test for September 1971. This nuclear test was in the low yield range of less than 20 kilotons TNT equivalent. It was conducted on September 29, 1971, at the U.S. Atomic Energy Commission's Nevada Test Site in the Yucca basin, 1,240 feet below the desert floor.

Not all of the nuclear detonations in the United States are announced immediately, therefore, the information in this section may not be complete. A complete list of announced U. S. nuclear detonations may be obtained upon request from the Division of Public Information, U. S. Atomic Energy Commission, Washington, D. C. 20545.

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☆U. S. GOVERNMENT PRINTING OFFICE: 1971-484-490/3

SYNOPSES

Synopses of reports, incorporating a list of key words, are furnished below in reference card format for the convenience of readers who may wish to clip them for their files.

A JOINT X-RAY RADIATION SURVEY IN PUERTO RICO, 1968. *Michael Gileadi. Radiological Health Data and Reports, Vol. 12, October 1971,* pp. 495–499.

The objectives, scope, and methods used in the 1968 Joint Radiation Survey Project, sponsored jointly by the Puerto Rico Nuclear Center and by the Department of Health of the Commonwealth of Puerto Rico, are described. The most significant results concerning the western and southern regions of the Island are presented. Most of the three quantifiers (mean gonadal dose, per capita per annum gonadal dose, and genetically significant dose) were smaller in the southern region than those in the western region.

KEYWORDS: Puerto Rico, radiation, survey, x ray.

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RADIOLOGICAL HEALTH DATA AND REPORTS

Volume 12, Number 11, November 1971

Radiological Health Data and Reports, a monthly publication of the Environmental Protection Agency, presents data and reports provided by Federal, State, and foreign governmental agencies, and other cooperating organizations. Pertinent original data and interpretive manuscripts are invited from investigators.

In August 1959, the President directed the Secretary of Health, Education, and Welfare to intensify Departmental activities in the field of radiological health. The Department was assigned responsibility within the Executive Branch for the collation, analysis, and interpretation of data on environmental radiation levels. This responsibility was delegated to the Bureau of Radiological Health, Public Health Service. Pursuant to the Reorganization Plan No. 3 of 1970, effective December 2, 1970, this responsibility was transferred to the Radiation Office of the Environmental Protection Agency which was established by this reorganization.

The Federal agencies listed below appoint their representatives to a Board of Editorial Advisors. Members of the Board advise on general publications policy; secure appropriate data and manuscripts from their agencies; and review those contents which relate to the special functions of their agencies.

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Acting Deputy Assistant Administrator
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ENVIRONMENTAL PROTECTION AGENCY
William D. Ruckelshaus, Administrator

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Reports

Strontium-90 in Human Vertebrae in Czechoslovakia, 1964-1969

Z. Březík[1]

The Institute of Radiation Hygiene has been conducting a continuous determination of strontium-90 in human vertebrae since the beginning of 1964. Specimens were collected at autopsies of inhabitants of Prague and Middle Bohemia, aged 0–60 years. In the period, 1964–1969 about 1,450 specimens were analyzed and the results divided into 12 age groups. The peak strontium-90 level occurred in 1964 in child group 6–11 months. In the following years, the decreasing trend of strontium-90 values is evident especially in child groups. A frequency histogram of values obtained displays a slightly positive skewness in all years of the study. When plotted, the data indicate a log normal distribution.

Since the beginning of 1964, the Institute of Radiation Hygiene in Prague has carried out determinations of strontium-90 in human vertebrae. The bodies of lumbar vertebrae (in children up to 1 year of age, the thoracic vertebrae too) were collected from deceased inhabitants of Prague and Middle Bohemia, aged 0–60 years. The specimens were taken by pathologists at the Institute of Forensic Medicine and at the Institute of Pathology and Microbiology, Charles University, Prague. All specimens were selected to exclude those whose history reflected a calcium deficiency. About 1,450 specimens of vertebrae have been analyzed from 1964 through 1969.

Analysis

All determinations were made using the method of Bryant et al. (*1*), only radium-226 separation was carried out by the method of precipitation from a homogeneous solution (*2*).

The chemical yields of strontium and yttrium carriers were determined by complexometric titration with EDTA. The indirect complexometric titration procedure was used for the determination of calcium content in bone ash.

The beta activity of yttrium-90 samples was measured using gas flow anticoincidence counters (CE 14, Tracerlab, USA and RA 12, Intertechnique, France). The background of the four counters used was 0.24, 0.99, 0.66 and 1.24 cpm, respectively. The interlaboratory comparison of strontium-90 determination in bones conducted by the International Atomic Energy Agency in Vienna in 1964 showed a good agreement of our results with the expected values.

Discussion

Table 1 lists the levels of strontium-90 in human vertebrae in pCi/g Ca for the 1964–1969 period. The sets of samples are divided into 12 age groups: stillborn and newborn, 0–5 months, 6–11 months, 1, 2, 3, 4, 5–11, 12–18, 19–29, 30–39, 40–60 years of age. From figure 1 it is evident that the course of strontium-90 values depends on age. The peak values are concentrated especially in child groups around 1 year of age. The highest values in these age groups were found in 1964. In the following years the decreasing trend of values is evident. The values for adults above 19 years of age do not vary substantially throughout the whole survey period.

Before calculating the average value for each age group, the outlying observations were tested

---

[1] Ing. Březík is with the Institute of Hygiene and Epidemiology, Department of Radiation Hygiene, Prague, Czechoslovakia.

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Table 1. Strontium-90 in human vertebrae by year of death and age in Czechoslovakia

Group	Age (years)	Strontium-90 to calcium ratio (pCi/g)					
		1964	1965	1966	1967	1968	1969
1	Stillborn and newborn	ᵃ4.57 ±0.80 (17) 1.44–7.76	4.00 ±0.90 (37) 0.72–10.70	2.21 ±0.40 (30) 0.70–5.05	1.65 ±0.26 (31) 0.64–3.69	—	—
2	0–5 months	5.38 ± .74 (36) 2.17–11.4	3.48 ±0.54 (36) .74–7.21	2.95 ± .46 (47) .57–7.23	2.60 ± .34 (55) .61–5.62	—	—
3	6–11 months	12.3 ±3.0 (7) 7.77–19.3	6.78 ±1.32 (11) 3.34–10.9	4.28 ± .46 (16) 2.95–6.61	3.07 ± .46 (36) .66–6.45	1.41 ±0.09 (1)	—
4	1	8.21 ± 1.33 (6) 7.22–11.3	6.86 ±1.86 (10) 1.62–12.2	3.50 ± .66 (9) 1.89–4.91	4.10 ± .86 (20) .71–8.54	2.38 ± .51 (4) 2.07–3.16	3.24 ±0.43 (23) 1.38–5.95
5	2	2.96 ±1.27 (4) 1.63–4.43	3.45 ±1.25 (5) 1.08–4.62	3.26 ± .47 (8) 2.30–4.22	3.82 ± .67 (12) 2.04–6.06	6.38 ±1.42 (2) 5.66–7.11	2.33 ± .44 (9) 1.16–3.30
6	3	3.90 ±1.79 (6) 2.30–7.81	4.20 ±1.15 (8) 2.38–7.20	3.83 ± .81 (11) 2.36–6.59	2.89 ± .52 (12) 1.18–4.64	2.48 ± .39 (5) 2.01–3.03	2.80 ± .73 (10) 1.72–4.84
7	4	4.04 ±2.50 (3) 1.73–6.16	5.46 ±3.43 (3) 2.66–8.68	3.02 ±1.20 (5) 1.62–5.86	2.89 ± .58 (9) 1.69–4.39	4.35 ±1.30 (5) 2.38–6.36	2.96 ± .63 (10) 1.46–5.00
8	5–11	2.73 ± .65 (20) .26–6.21	3.16 ± .46 (21) 1.63–5.58	2.66 ± .24 (21) 1.26–5.14	2.66 ± .35 (33) .85–5.32	1.68 ± .46 (7) 1.21–2.96	2.28 ± .28 (28) 1.05–3.73
9	12–18	3.18 ± .53 (25) .56–6.02	3.72 ± .56 (34) .47–7.23	3.00 ± .33 (38) .81–4.96	2.90 ± .38 (35) .97–6.24	2.20 ± .64 (4) 1.35–2.80	2.52 ± .33 (31) .42–4.25
10	19–29	2.16 ± .43 (18) .89–4.26	2.26 ± .24 (52) .41–4.47	2.10 ± .23 (43) .79–4.60	2.09 ± .23 (39) 1.06–4.15	1.97 ± .57 (2) 1.68–2.26	2.04 ± .48 (7) 1.30–2.92
11	30–39	1.52 ± .41 (13) .31–2.83	2.08 ± .22 (23) 1.29–3.17	1.73 ± .20 (29) .91–3.08	1.94 ± .20 (39) 1.14–3.66	1.43 ± .24 (7) 1.14–2.05	1.80 ± .15 (21) 1.28–2.67
12	40–60	1.63 ± .14 (47) .94–2.70	2.12 ± .17 (66) .44–3.82	1.66 ± .20 (31) .16–2.53	1.80 ± .23 (44) .67–4.36	1.75 ± .16 (45) .95–2.93	1.61 ± .14 (34) .78–2.47

ᵃ The upper left number is the mean value ±2 S.E. The number in parentheses indicates the number of samples. The lower numbers indicate the range of values found in that group.

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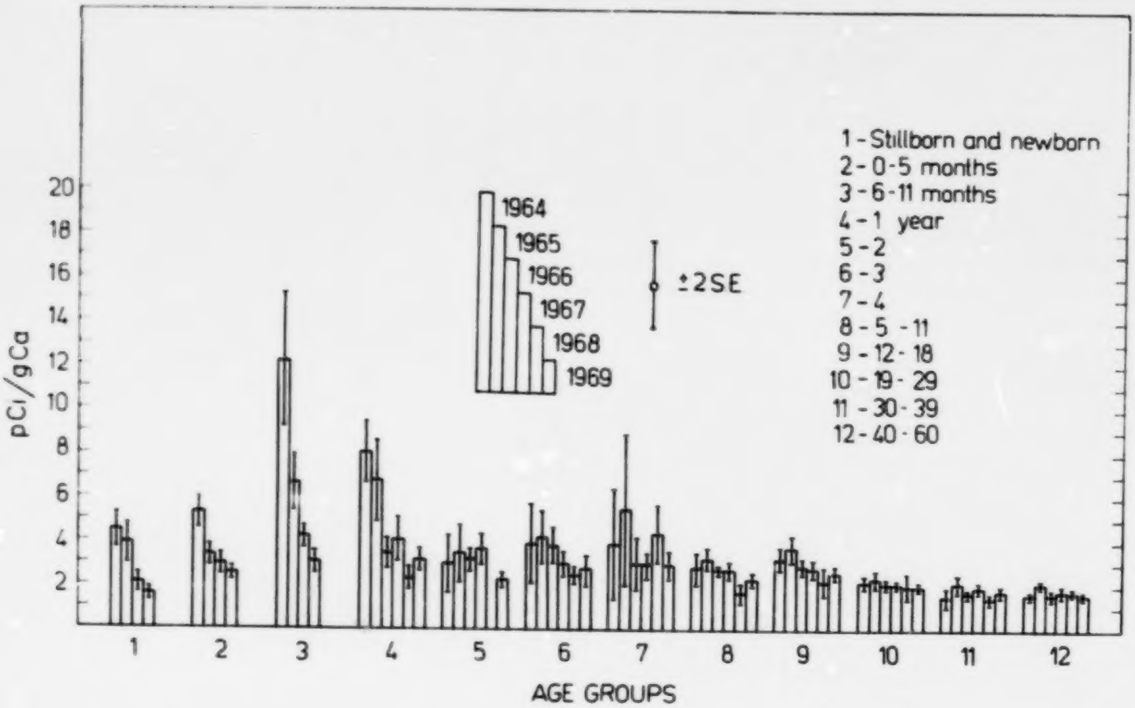

Figure 1. Strontium-90 to calcium ratios in human vertebrae by year of death and age

Table 2. Statistically outlying observations

Year	Group	pCi ^{90}Sr/g Ca	Group	pCi ^{90}Sr/g Ca
1964	1	35.9 ± 1.7	9	8.5 ± 0.5 10.0 ± .4
	2	12.1 ± 1.0 15.1 ± 1.5 17.9 ± .9 32.9 ± 1.8	12	25.9 ± .8
1965	2	10.7 ± 1.4 11.5 ± 1.2 14.0 ± 1.0 17.3 ± 1.0 44.9 ± 2.9	3	17.8 ± 1.0
			5	17.0 ± 1.2
			8	7.8 ± .5
			10	30.7 ± 1.3
1966	1	60.6 ± 4.9	8	6.5 ± .6 19.0 ± 1.2
	2	9.9 ± .8	9	8.5 ± .4
	4	7.4 ± .6		
1967	1	5.6 ± .5 6.3 ± .6 7.8 ± .6	2	8.1 ± .6
1968	4	5.2 ± .4	8	5.9 ± .4
1969	4	12.4 ± .9 17.9 ± 1.2 20.6 ± .8	7	14.4 ± 1.3
			8	5.1 ± .3 8.4 ± .6

according to the method of Grubbs (*3*). The values of the outlying observations are summarized in table 2.

The frequency histograms of strontium-90 to calcium ratios were drawn for individual years of the followup. Figure 2 shows the histogram for the year 1966. In all years the histograms display a slightly positive skewness. A plot of data indicates a log normal distribution of values (figure 3), which is in good agreement with earlier observations on biological materials (*4*).

Summary

From 1964 through 1969 about 1,450 specimens of human vertebrae were analyzed for strontium-90. The results are divided into 12 age

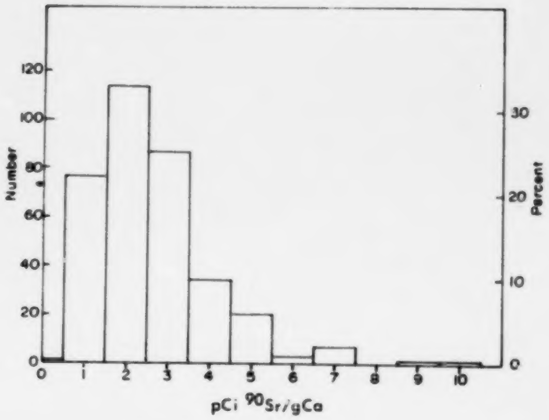

Figure 2. Frequency distribution of strontium-90 to calcium ratios for 1966

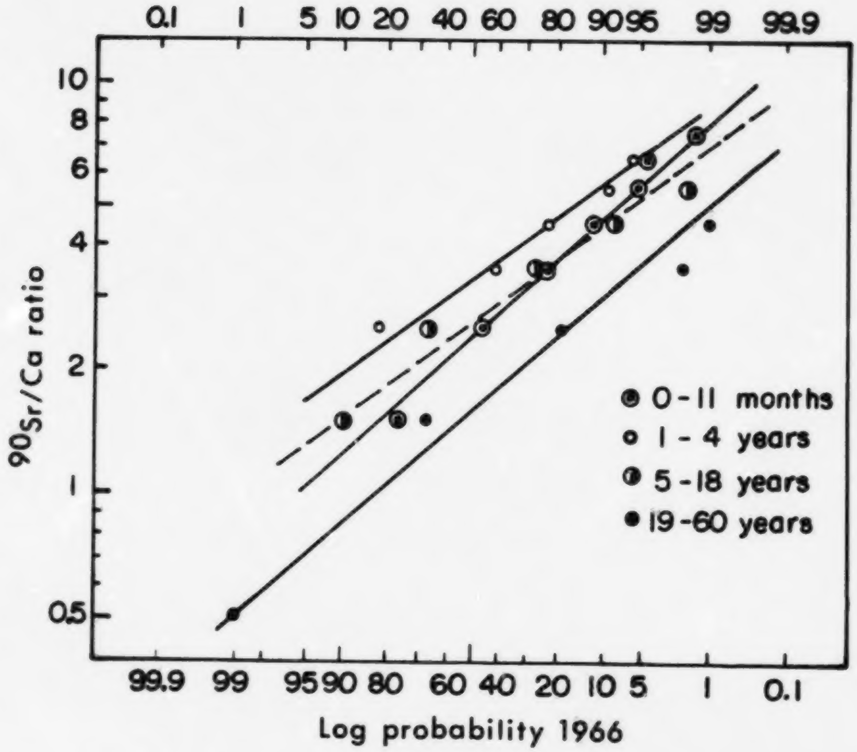

Figure 3. Log probability plot of strontium-90 to calcium ratios by age group for 1966

groups. A review of the data shows that peak strontium-90 levels occurred in most age groups during 1964. In the following years the decreasing trend of strontium-90 values is evident especially in child groups. The strontium-90 values for adults remain practically the same throughout the whole period. The frequency histograms as well as the plot of the data indicate a log normal distribution.

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EDITOR'S NOTE:

It may be of interest to compare the data of Ing. Březík with those obtained during a corresponding period in the United States and some European countries. The data in table 3 were assembled from a number of available sources (*1–5*). It should be noted that the U.S. ratio for strontium-90 to calcium in bone is an average which includes values for "wet" and "dry" areas as defined by the Federal Radiation Council (*6,7*). The spread between the ratios in these areas is substantial and could easily overlap the values observed in the European countries, given comparable latitude and climatic conditions. The log normal distribution of the data in the Czechoslovakia study is apparently characteristic. A similar relationship was reported for the United States (*8*).

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Table 3. Average strontium-90 ratios (pCi/g Ca) in human bone United States, Germany, and England

Age group	Year	PHS	AEC[a]	Germany	England
0–4	1963	[b]4.3(44)	3.6(72)	3.7(30)	4.7(165)
	1964	4.3(68)	3.6(64)	5.4(36)	7.9(130)
	1965	3.9(83)	4.3(43)	5.9(19)	7.9(84)
	1966	3.7(67)	2.9(59)	[c]2.9(95)	[d]—
	1967	3.8(111)	2.0(89)	—	—
	1968	3.3(63)	1.9(42)	—	—
	1969	2.6(42)	1.3(125)	—	—
5–19	1963	3.2(163)	1.8(64)	1.4(27)	1.6(74)
	1964	3.2(178)	2.7(67)	2.8(28)	2.2(46)
	1965	2.7(160)	2.9(58)	2.7(13)	2.8(41)
	1966	2.5(193)	2.5(35)	3.0(21)	—
	1967	2.8(299)	2.2(39)	—	—
	1968	2.5(278)	2.9(47)	—	—
	1969	2.2(258)	2.0(50)	—	—

[a] Average of tri-city study (New York City, Chicago, San Francisco); Chicago samples not collected after 1965.
[b] Parentheses give number of samples making up average.
[c] A rather large percentage of the material in this group consisted of specimens 10 days old or less, including fetuses.
[d] Dash means data not available.

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Results of a Survey of X Radiation from Color Television Receivers in the Metropolitan Area of San Juan, Puerto Rico, 1969-1970

Radiological Health Program
Commonwealth of Puerto Rico Department
of Health

In 1969–1970, the Puerto Rico Department of Health surveyed 1,276 color television sets for emission of radiation. Only 34 (2.7 percent) of these sets were found to be emitting x radiation in excess of 0.5 mR/h at 5 cm from the surface of the receiver.

It is known that color television receivers may emit x radiation. The National Council on Radiation Protection and Measurements (NCRP) recommended that color television sets not emit x rays with exposure rates above 0.5 mR/h at 5 cm from the accessible surface (*1*). In December 1969, a Federal regulation was adopted making this standard mandatory for all new television receivers.

Various surveys conducted in different States indicate that many color television sets emit x radiation above the recommended value (*2–4*).

In an effort to disclose the magnitude of the problem in Puerto Rico, the Radiological Health Program of the Health Department conducted a similar survey in the Metropolitan Area of San Juan, Puerto Rico. It was divided into two phases: a preliminary and a final one.

The preliminary survey consisted of visits to the manufacturers, distributors, and dealers, as well as home visits, for inspection of television sets. The final survey consisted only of home visits for inspection and reinspection of sets found emitting x radiation above the recommended value, once they were repaired.

A total of 1,276 television sets were surveyed. Of these, 279 were inspected in the visits made to manufacturers, distributors, and dealers, while the rest, 997 television sets, were inspected during home visits. Although the survey has been finished, further calls requesting inspection of television sets are being accepted, and an inspection is being performed by our personnel.

Methods and operations

Visits to manufacturers, distributors, and dealers as well as home visits were started in the summer of 1969. Since only one team was conducting the survey, it took about 1 year to complete the whole survey.

The preliminary survey was divided in two phases. The first phase consisted of visits to manufacturers, distributors, and dealers of color television receivers in Puerto Rico. The second phase and the final survey consisted of visits to homes of television set owners.

The objectives of the visits to the manufacturers, distributors, and dealers were:

1. To make them aware of the problem of x-ray emission from color television receivers.
2. To obtain a list of the owners of color television receivers in Puerto Rico. (At the time of the study there were approximately 60,000 color television sets in Puerto Rico).
3. To make an evaluation of the x-ray emission from the television sets in stock.
4. To have the industry provide corrective service and cooperate with us in finding out what was wrong with the sets that were

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found emitting radiation above the recommended value.

5. To determine the most probable factors affecting x-radiation emissions from television sets.

The objectives of the visits to the homes were:

1. To survey all the accessible surfaces of the televisions receivers for x rays.
2. To record (a) the model, serial number, and screen size, (b) the purchase date, (c) the distance from which the set is viewed, and (d) the servicing done to the set before the scanning and by whom it was performed.
3. To instruct the color television viewers of the possible radiation hazards and how to protect themselves.

At first, home visits did not turn out well. Many persons, whose names and addresses we had obtained from the distributors, were not at home when we went to make the survey. In addition, the people's distrust as to the purpose of our visit hampered us from surveying their sets.

In an effort to accomplish our survey satisfactorily, we decided to modify the procedure. We no longer used the list of names provided by the distributors. Instead, a press release was made to inform the public of our survey, and at the same time, inviting them to let us know if they were interested in having their sets surveyed. In this manner, the difficulties which hampered the progress of our survey came to an end.

A list of all the people interested in having their sets surveyed was made and allocated by areas. Every morning, telephone calls were made to those owners living in the metropolitan area which we were to cover. When set owners could not be reached by telephone, we called in person.

Before inspecting the television sets, an interview was conducted with the set owners. In it, special attention was placed on instructing them how to protect themselves from radiation from their television set, for example, keeping at least 6 feet from the set, and having the television set repaired only by expert personnel. After the interview, the inspection was carried out.

In the beginning of this survey, the scannings were performed with a Thyac III Victoreen Geiger-Mueller Counter. Later on, the scannings were performed with another instrument consisting of an array of six Victoreen type 1B85 Geiger-Mueller counters (*5–6*).

Whenever a set was found emitting x radiation above recommended limits, the owner was informed that servicing was needed in order to correct the television receiver. In addition, the distributor was immediately contacted so that appropriate corrections could be made. Prior to beginning the survey, the distributors had agreed that they would repair any sets found emitting x rays above the standards and inform the health department of the corrections and adjustments.

Once these sets were repaired, they were reinspected. The entire procedure was repeated until the television set was found to be within the recommended radiation value.

The preliminary survey

In the preliminary survey we were able to evaluate a total of 575 sets, 279 in the first phase and 296 in the second phase.

The sets surveyed in the first phase of the preliminary survey from the manufacturers, distributors, and dealers (table 1) should not be considered in the final results because there are other possible variables present in the homes where the sets are finally installed which could make them emit x radiation, e.g. variation in the

Table 1. Distribution of color television sets by the x-radiation exposure rate in the first phase of the preliminary survey (in mR/h at 5 cm from the surface of the set)

Brand or manufacturer	0 to ≤0.5
Admiral	
Andrea	10
Curtis Mathes	4
Emerson	19
General Electric	5
Hotpoint	20
Magnavox	2
Motorola	12
Olympic	13
Packard-Bell	2
Panasonic	7
Penncrest	5
Philco	5
RCA	30
Sears	7
Setchell Carlson	5
Sharp	3
Silvertone	17
Sylvania	33
Toshiba	6
Westinghouse	14
Zenith	14
	46
Grand total	279

line voltage, that would not be found in the sets provided by the manufacturers, distributors, and dealers.

Of those surveyed in the second phase of the preliminary survey, eight were found emitting x rays above the recommended value (table 2). Three of them emitted x rays with exposure rates above 0.5 mR/h but less than 1.0 mR/h. The other five sets emitted x rays above 1.0 mR/h, but not beyond 5.0 mR/h. These emissions were detected at the anterior surface in two sets, at the posterior surface in two sets, at the left (of the viewer) lateral surface in two sets, at the top surface in one set and at the top and right lateral surfaces in one set.

Table 2. Distribution of color television sets by the x-radiation exposure rate in the second phase of the preliminary survey (in mR/h at 5 cm from the surface of the set)

Brand or manufacturer	Total	0 to ≤0.5	>0.5 to <1.0	≥1.0 to 5.0
Admiral	11	11	0	0
Andrea	4	4	0	0
Curtis Mathes	27	26	0	1
Emerson	5	5	0	0
Del Monico	1	1	0	0
General Electric	40	39	0	1
Heathkit	1	1	0	0
Hotpoint	2	2	0	0
Magnavox	11	11	0	0
Motorola	4	4	0	0
Olympic	2	2	0	0
Packard-Bell	2	2	0	0
Panasonic	18	18	0	0
Penncrest	5	5	0	0
Philco	9	8	1	0
RCA	11	10	1	0
Sears	43	42	1	0
Setchell Carlson	5	5	0	0
Sharp	2	2	0	0
Silvertone	19	19	0	0
Sylvania	17	17	0	0
Toshiba	13	12	0	1
True-Tone	1	1	0	0
Westinghouse	17	17	0	0
Zenith	26	24	0	2
Grand total	296	288	3	5

All eight television sets found emitting radiation above allowable standards were reported to the distributors for corrective service; repair reports were received from the distributors. In five of the television sets, the high voltage had to be adjusted; the highest voltage excess (above normal operating conditions) found was 4.0 kV. The shunt regulator was found to be the only source of excess emission in two sets, and the picture tube in one set. The corrective servicing for sets with x-radiation emissions above 0.5 mR/h consisted of adjustments of high voltage and replacement of component parts. A total of two shunt regulators and one picture tube were replaced.

It was found that out of the 296 sets inspected, 117 owners of color television receivers watched their sets from distances of less than 6 feet. One of the sets emitted radiation at a higher exposure rate than recommended. The remaining 179 owners kept distances greater than 6 feet but not farther than 10 feet. Seven television sets of this second group emitted radiation at a rate greater than 0.5 mR/h.

Finally we observed that only a small fraction (1.7 percent) of the population visited in this preliminary survey serviced their own television receivers. The majority of this small fraction were television repairmen.

The final survey

In the final survey, a total of 701 television sets were surveyed. Of these 675 were found to be emitting radiation between 0 and 0.5 mR/h (table 3).

Only 26 television sets were found emitting x radiation above the recommended value (table 3). Of these 26 television sets, 22 were emitting radiation at levels below 1.0 mR/h, and four at or above 1.0 mR/h. The highest value found was 1.6 mR/h. Of the 26 sets found emitting x radiation, 10 had the highest level of radiation emission at

Table 3. Distribution of color television sets by the x-radiation exposure rate in final survey (in mR/h at 5 cm from the surface of the set)

Manufacturer	Total	0 to ≤0.5	>0.5 to <1.0	≥1.0 to 5.0
Admiral	26	24	2	0
Curtis Mathes	94	90	4	0
Dumont	2	2	0	0
Emerson	8	8	0	0
General Electric	101	99	2	0
Heathkit	2	2	0	0
Hotpoint	5	5	0	0
Magnavox	27	25	1	1
Motorola	5	5	0	0
Nivico	1	1	0	0
Olympic	2	2	0	0
Packard-Bell	10	9	0	1
Panasonic	25	24	1	0
Penncrest	22	22	0	0
Philco	13	13	0	0
RCA	27	24	3	0
Sears	50	44	5	1
Setchell Carlson	3	3	0	0
Sharp	6	6	0	0
Silvertone	86	86	0	0
Singer	3	3	0	0
Sony	1	1	0	0
Sylvania	50	49	1	0
Toshiba	22	22	0	0
Westinghouse	44	43	0	1
Zenith	66	63	3	0
Grand total	701	675	22	4

the posterior surface, seven at the anterior surface, one at the bottom, four at the left lateral surface, three at the top and one at the right lateral surface.

All 26 television sets found to be emitting radiation above normal levels were reported to the distributors for corrective service; repair reports were received from the distributors. In 16 television sets, only the voltage had to be adjusted; the highest voltage excess found above normal operating conditions was 6.0 kV. The shunt regulator was found to be the only source of excess emission in seven television sets, the picture tube in one set, the rectifier tube in one set, and a combination of voltage and picture tube in one set.

The corrective servicing for those sets with x-radiation emissions above 0.5 mR/h consisted of replacement of components and/or adjusting the operating high voltage to recommended operating levels. A total of seven shunt regulators, one rectifier tube, and two picture tubes were replaced.

It was found that 55 owners of television sets watched their sets from a distance of less than 6 feet. Three of the sets were emitting x radiation above 0.5 mR/h. It was also found that only 1.4 percent of the owners service their television sets.

Table 4. Distribution of color television sets by the x-radiation exposure rate in home visits of preliminary and final surveys (in mR/h at 5 cm from the surface of the set)

Manufacturer	Total	0 to ≤0.5	>0.5 to <1.0	≥1.0 to 5.0
Admiral	37	35	2	0
Andrea	4	4	0	0
Curtis Mathes	121	116	4	1
Del Monico	1	1	0	0
Dumont	2	2	0	0
Emerson	13	13	0	0
General Electric	141	138	2	1
Heathkit	3	3	0	0
Hotpoint	7	7	0	0
Magnavox	38	36	1	1
Motorola	9	9	0	0
Nivico	1	1	0	0
Olympic	4	4	0	0
Packard-Bell	12	11	0	1
Panasonic	43	42	1	0
Penncrest	27	27	0	0
Philco	22	21	1	0
RCA	38	34	4	0
Sears	93	86	6	1
Setchell Carlson	8	8	0	0
Sharp	8	8	0	0
Silvertone	105	105	0	0
Singer	3	3	0	0
Sony	1	1	0	0
Sylvania	67	66	1	0
Toshiba	35	34	0	1
True-tone	1	1	0	0
Westinghouse	61	60	0	1
Zenith	92	87	3	2
Grand total	997	963	25	9

Summary

A total of 1,276 television sets was surveyed. Of these, 279 were inspected at manufacturers, distributors and dealers. The rest (997 television sets) were inspected in home visits. Of these 997 television sets, 963 television sets were emitting x radiation at or below 0.5 mR/h (table 4).

Of those television sets inspected at manufacturers, distributors, and dealers, none was found emitting radiation above the recommended level. Of those inspected in home visits, only 34 were found emitting x radiation above the recommended value (table 4). The highest value found was 1.6 mR/h. Of these 34 sets, 12 had the highest level of radiation emission measured at the posterior surface, nine at the anterior, six at the left lateral, four at the top, one at the bottom, one at the top and right lateral, and one at the right lateral surface (table 5).

Discussion

The purpose of this survey was to evaluate the magnitude of the problem of color television sets emitting x radiation in the metropolitan area of San Juan, Puerto Rico. Although different makes and models were surveyed, no relationship can be established between makes and models and x-radiation emission. That requires a greater sample and a better representation of each make and model.

Out of the 997 television sets surveyed in home visits, only 34 were found emitting above 0.5 mR/h, which represents 3.4 percent of the total surveyed. This percentage is lower than those found in other surveys (*2-4*).

The results obtained in our survey confirm that industry is capable of producing television sets within the recommendations made by the NCRP. Even so, further improvements should be made in order to keep to a minimum the chances of unnecessary x-radiation emission.

Conclusions

1. X-ray emission from color television sets occurs in Puerto Rico and was observed in various makes and models of the 1,273 sets surveyed.
2. Only 3.4 percent of the television sets surveyed

Table 5. Distribution of color television sets found in the preliminary and final surveys emitting radiation above the recommended level (including surface measured and source of radiation)

Manufacturer	Level of emission (mR/h)	Surface	Source of radiation
Admiral	0.8	Anterior	Shunt regulator
	.6	Right lateral	High voltage
Curtis Mathes	.6	Posterior	Picture tube
	.7	Posterior	Picture tube
	.6	Bottom	Shunt regulator
	.7	Left lateral	High voltage
	1.0	Posterior	Picture tube and high voltage
General Electric	.6	Posterior	Shunt regulator
	1.4	Posterior	High voltage
	.6	Posterior	High voltage
Magnavox	1.6	Left lateral	High voltage
	.6	Top	High voltage
Packard-Bell	1.5	Anterior	Picture tube
Panasonic	.6	Top	High voltage
Philco	.5	Anterior	High voltage
RCA	.6	Left lateral	Shunt regulator
	.6	Top	High voltage
	.6	Anterior	High voltage
	.6	Anterior	High voltage
Sears	.8	Top and right lateral	Rectifier tube
	1.0	Top	High voltage
	.6	Posterior	High voltage
	.6	Posterior	High voltage
	.6	Posterior	High voltage
	.6	Posterior	High voltage
	.7	Posterior	High voltage
Sylvania	.8	Left lateral	Shunt regulator
Toshiba	1.0	Left lateral	Shunt regulator
Westinghouse	1.0	Posterior	High voltage
Zenith	.6	Anterior	High voltage
	1.0	Anterior	High voltage
	.5	Anterior	High voltage
	1.0	Anterior	High voltage
	.7	Left lateral	Shunt regulator

were found to be emitting x rays above 0.5 mR/h.

3. Operating high voltage affects production and emission of x radiation from components.
4. The main sources of x radiation are excessive high voltage, the shunt regulator, the rectifier tube, and the picture tube.
5. Proper servicing reduces the x radiation to a permissible level.

Acknowledgments

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SECTION I. MILK AND FOOD

Milk Surveillance, July 1971

Although milk is only one of the sources of dietary intake of environmental radioactivity, it is the food item that is most useful as an indicator of the general population's intake of radionuclide contaminants resulting from environmental releases. Fresh milk is consumed by a large segment of the population and contains several of the biologically important radionuclides that may be released to the environment from nuclear activities. In addition, milk is produced and consumed on a regular basis, is convenient to handle and analyze, and samples representative of general population consumption can be readily obtained. Therefore, milk sampling networks have been found to be an effective mechanism for obtaining information on current radionuclide concentrations and long-term trends. From such information, public health agencies can determine the need for further investigation or corrective public health action.

The Pasteurized Milk Network (PMN) sponsored by the Office of Radiation Programs, Environmental Protection Agency, and the Office of Food Sanitation, Food and Drug Administration, U.S. Public Health Service, consists of 63 sampling stations: 61 located in the United States, one in Puerto Rico, and one in the Canal Zone. Many of the State health departments also conduct local milk surveillance programs which provide more comprehensive coverage within the individual State. Data from 15 of these State networks are reported routinely in *Radiological Health Data and Reports*. Additional networks for the routine surveillance of radioactivity in milk in the Western Hemisphere and their sponsoring organizations are:

Pan American Milk Sampling Program (Pan American Health Organization and U.S. Environmental Protection Agency)—5 sampling stations

Canadian Milk Network (Radiation Protection Division, Canadian Department of National Health and Welfare)—16 sampling stations.

The sampling locations that make up the networks presently reporting in *Radiological Health Data and Reports* are shown in figure 1. Based on the similar purpose for these sampling activities, the present format integrates the complementary data that are routinely obtained by these several milk networks.

Radionuclide and element coverage

Considerable experience has established that relatively few of the many radionuclides that are formed as a result of nuclear fission become incorporated in milk (*1*). Most of the possible radiocontaminants are eliminated by the selective metabolism of the cow, which restricts gastrointestinal uptake and secretion into the milk. The five fission-product radionuclides which commonly occur in milk are strontium-89, strontium-90, iodine-131, cesium-137, and barium-140. A sixth radionuclide, potassium-40, occurs naturally in 0.0118 percent (*2*) abundance of the element potassium, resulting in a specific activity for potassium-40 of 830 pCi/g total potassium.

Two stable elements which are found in milk, calcium and potassium, have been used as a means for assessing the biological behavior of metabolically similar radionuclides (radiostron-

60

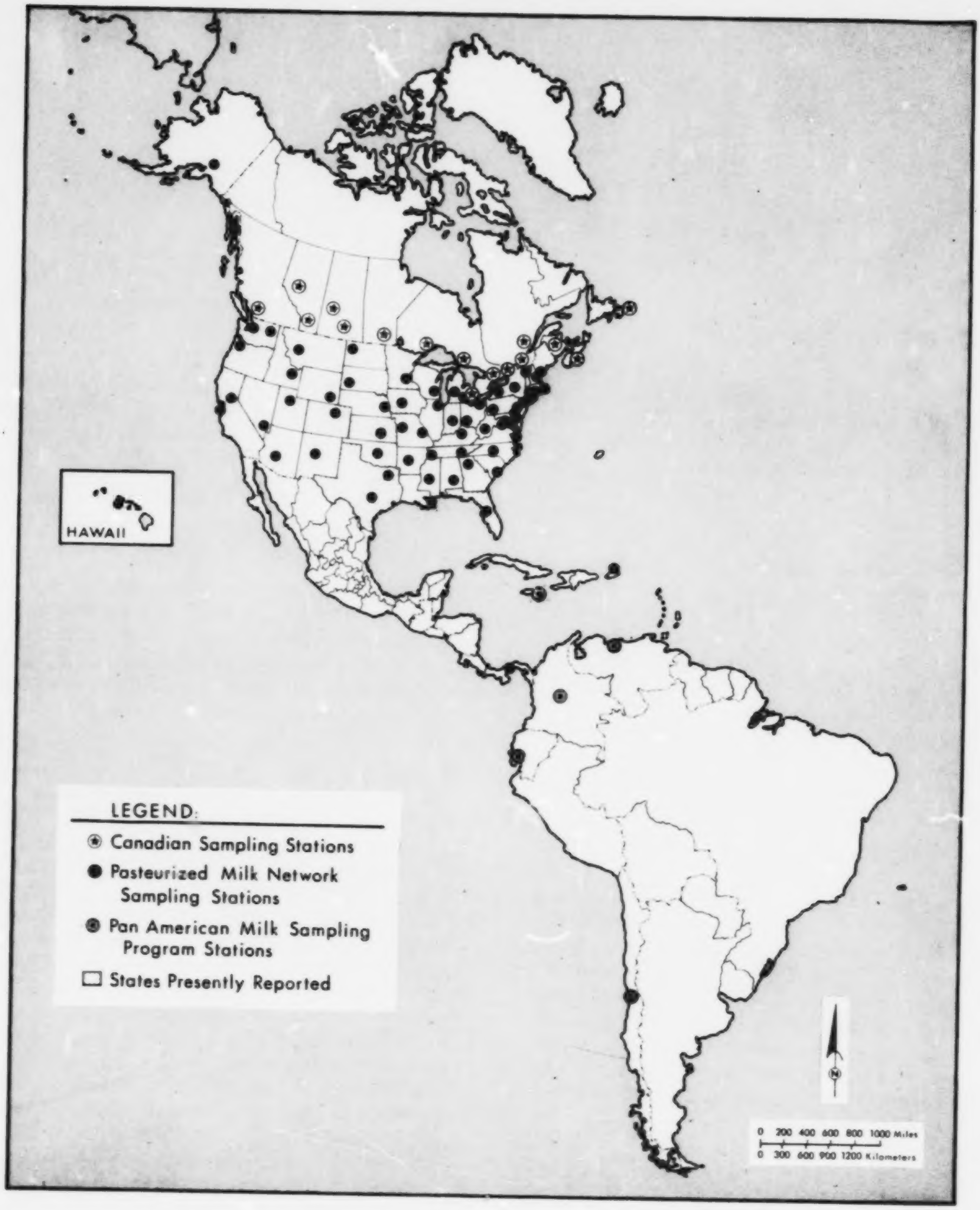
HAWAII
LEGEND:
⊛ Canadian Sampling Stations
● Pasteurized Milk Network Sampling Stations
◉ Pan American Milk Sampling Program Stations
☐ States Presently Reported
N
0 200 400 600 800 1000 Miles
0 300 600 900 1200 Kilometers

Figure 1. Milk sampling networks in the Western Hemisphere

tium and radiocesium, respectively). The contents of both calcium and potassium in milk have been measured extensively and are relatively constant. Appropriate values and their variations, expressed in terms of 2 standard deviations (2σ), for these elements are 1.16 ± 0.08 g/liter for calcium and 1.51 ± 0.21 g/liter for potassium. These figures are averages of data from the PMN for May 1963–March 1966 (*3*) and were determined for use in general radiological health calculations or discussions.

Accuracy of data from various milk networks

In order to combine data from the international, national, and State networks considered in this report, it was first necessary to determine the accuracy with which each laboratory is making its determinations and the agreement of the measurements among the laboratories. The Analytical Quality Control Service of the Office of Radiation Programs conducts periodic studies to assess the accuracy of determinations of radionuclides in milk performed by interested radiochemical laboratories. The generalized procedure of making such a study has been outlined previously (*4*).

The most recent study was conducted during May–July 1970, with 28 laboratories participating in an experiment on milk samples containing known concentrations of strontium-89, strontium-90, iodine-131, cesium-137, and barium-140 (*5*). Of the 18 laboratories producing data for the networks reporting in *Radiological Health Data and Reports*, 13 participated in the experiment.

The accuracy results of this experiment are shown in table 1. In general, considerable improvement is needed, especially in the accuracy measurements. These possible differences should be kept in mind when considering the integration of data from the various networks.

Development of a common reporting basis

Since the various networks collect and analyze samples differently, a complete understanding of several parameters is useful for interpreting the data. Therefore, the various milk surveillance networks that report regularly were surveyed for information on analytical methods, sampling and analysis frequencies, and estimated analytical errors associated with the data.

In general, radiostrontium is collected by an ion-exchange technique and determined by beta-particle counting in low-background detectors, and the gamma-ray emitters (potassium-40, iodine-131, cesium-137, and barium-140) are determined by gamma-ray spectroscopy of whole milk. Each laboratory has its own modifications

Table 1. Distribution of mean results, quality control experiment

Isotope and known concentration		Number of laboratories in each category			
		Acceptable[a]	Warning level[b]	Unacceptable[c]	Total
Strontium 89:	High (258 pCi/liter)	7 (44%)	1 (6%)	8 (50%)	16
	Low (15 pCi/liter)	11 (69%)	3 (19%)	2 (12%)	16
Strontium-90:	Intermediate (79.4 pCi/liter)	13 (57%)	4 (17%)	6 (26%)	23
	Low (32.0 pCi/liter)	5 (25%)	4 (20%)	11 (55%)	20
Iodine-131:	High (507 pCi/liter)	18 (67%)	2 (7%)	7 (26%)	27
	Low (49 pCi/liter)	16 (64%)	3 (12%)	6 (24%)	25
Cesium-137	High (259 pCi/liter)	20 (74%)	3 (11%)	4 (15%)	27
	Low (53 pCi/liter)	17 (66%)	5 (19%)	4 (15%)	26
Barium-140:	High (302 pCi/liter)	18 (67%)	2 (7%)	7 (26%)	27
	Low (33 pCi/liter)	23 (92%)	0	2 (8%)	25

[a] Measured concentration equal to or within 2σ of the known concentration.
[b] Measured concentration outside 2σ and equal to or within 3σ of the known concentration.
[c] Measured concentration outside 3σ of the known concentration.

and refinements of these basic methodologies. The methods used by each of the networks have been referenced in earlier reports appearing in *Radiological Health Data and Reports.*

A previous article (*6*) summarized the criteria used by the State networks in setting up their milk sampling activities and their sample collection procedures as determined during a 1965 survey. This reference and an earlier data article for the particular network of interest may be consulted should events require a more definitive analysis of milk production and milk consumption coverage afforded by a specific network.

Many networks collect and analyze samples on a monthly basis. Some collect samples more frequently but composite the several samples for one analysis, while others carry out their analyses more often than once a month. Many networks are analyzing composite samples on a quarterly basis for certain nuclides. The frequency of collection and analysis varies not only among the networks but also at different stations within some of the networks. In addition, the frequency of collection and analysis is a function of current environmental levels. The number of samples analyzed at a particular sampling station under current conditions is reflected in the data presentation. Current levels for strontium-90 and cesium-137 are relatively stable over short periods of time, and sampling frequency is not critical. For the short-lived radionuclides, particularly iodine-131, the frequency of analysis is critical and is generally increased at the first measurement or recognition of a new influx of this radionuclide.

The data in table 2 show whether raw or pasteurized milk was collected. An analysis (*7*) of raw and pasteurized milk samples collected during January 1964 to June 1966 indicated that for relatively similar milkshed or sampling areas, the differences in concentration of radionuclides in raw and pasteurized milk are not statistically significant (*7*). Particular attention was paid to strontium-90 and cesium-137 in that analysis.

Practical reporting levels were developed by the participating networks, most often based on 2-standard-deviation counting errors or 2-standard-deviation total analytical errors from replicate analyses (*3*). The practical reporting level reflects analytical factors other than statistical radioactivity counting variations and will be used as a practical basis for reporting data.

The following practical reporting levels have been selected for use by all networks whose practical reporting levels were given as equal to or less than the given value.

Radionuclide	Practical reporting level (pCi/liter)
Strontium-89	5
Strontium-90	2
Iodine-131	10
Cesium-137	10
Barium-140	10

Some of the networks gave practical reporting levels greater than those above. In these cases the larger value is used so that only data considered by the network as meaningful will be presented. The practical reporting levels apply to the handling of individual sample determinations. The treatment of measurements equal to or below these practical reporting levels for calculation purposes, particularly in calculating monthly averages, is discussed in the data presentation.

Analytical error or precision expressed as pCi/liter or percent in a given concentration range has also been reported by the networks (*3*). The precision errors reported for each of the radionuclides fall in the following ranges:

Radionuclide	Analytical errors of precision (2 standard deviations)
Strontium-89	1–5 pCi/liter for levels <50 pCi/liter; 5–10% for levels ≥ 50 pCi/liter;
Strontium-90	1–2 pCi/liter for levels <20 pCi/liter; 4–10% for levels ≥ 20 pCi/liter;
Iodine-131 Cesium-137 Barium-140	4–10 pCi/liter for levels <100 pCi/liter; 4–10% for levels ≥ 100 pCi/liter.

For iodine-131, cesium-137, and barium-140, there is one exception for these precision error ranges: 25 pCi/liter at levels <100 pCi/liter for Colorado. This is reflected in the practical reporting level for the Colorado milk network.

Federal Radiation Council guidance applicable to milk surveillance

In order to place the U.S. data on radioactivity in milk presented in *Radiological Health Data and*

Table 2. Concentrations of radionuclides in milk for July 1971 and 12-month period August 1970 through July 1971

Sampling location		Type of sample[a]	Radionuclide concentration (pCi/liter)					
			Strontium-90		Iodine-131		Cesium-137	
			Monthly average[b]	12-month average	Monthly average[b]	12-month average	Monthly average[b]	12-month average
UNITED STATES:								
Ala:	Montgomery[c]	P	6	7	0	0	13	10
Alaska:	Palmer[c]	P	6	5	0	0	16	12
Ariz:	Phoenix[c]	P	0	0	0	0	0	0
Ark:	Little Rock[c]	P	11	12	0	0	15	13
Calif:	Sacramento[c]	P	0	1	0	0	0	0
	San Francisco[c]	P	8	4	0	0	0	0
	Del Norte	P	12	15	0	0	0	11
	Fresno	P	2	2	0	0	0	1
	Humboldt	P	4	5	0	0	0	4
	Los Angeles	P	2	2	0	0	0	0
	Mendocino	P	6	6	0	0	0	4
	Sacramento	P	2	3	0	0	0	1
	San Diego	P	0	1	0	0	0	1
	Santa Clara	P	0	2	0	0	0	1
	Shasta	P	3	3	6	0	0	3
	Sonoma	P	3	3	0	0	0	3
Colo:	Denver[c]	P	4	4	0	0	17	6
	West	R	(d)		[e]0	[e]0	[e]0	[e]0
	Northeast	R	(d)		[e]0 (6)	[e]0	[e]0 (6)	[e]1
	East	R	(d)		NS	[e]0	NS	[e]0
	Southeast	R	(d)		NS	[e]0	NS	[e]0
	South Central	R	(d)		NS	NS	NS	NS
	Southwest	R	(d)		[e]0	[e]0	[e]0	[e]3
	Northwest	R	(d)		[e]0	[e]4	[e]0	[e]0
Conn:	Hartford[c]	P	9	7	0	0	15	11
	Central	P	7	6	0	0	20	16
Del:	Wilmington[c]	P	10	9	0	0	17	7
D.C:	Washington[c]	P	9	7	0	0	14	10
Fla:	Tampa[c]	P	5	5	0	0	37	45
	Central	R	8	6	0	0	37	42
	North	R	5	8	0	0	33	26
	Northeast	R	7	7	0	0	48	34
	Southeast	R	7	7	0	1	70	72
	Tampa Bay area	P	6	6	0	0	41	46
	West	R	12	9	0	0	28	16
Ga:	Atlanta[c]	P	10	11	0	0	20	14
Hawaii:	Honolulu[c]	P	0	2	0	0	11	1
Idaho:	Idaho Falls[c]	P	6	5	0	0	0	6
Ill:	Chicago[c]	P	7	7	0	0	12	11
Ind:	Indianapolis[c]	P	7	7	0	0	0	7
	Northeast	P	8	9	0	0	25	15
	Southeast	P	12	10	0	0	20	15
	Central	P	8	8	0	5	15	12
	Southwest	P	8	10	0	0	35	13
	Northwest	P	8	10	0	0	20	13
Iowa:	Des Moines[c]	P	5	6	0	0	0	3
	Iowa City	P	9	8	0	0	21	15
	Des Moines	P	7	7	0 (3)	0	12 (3)	11
	Spencer	P	NS	NS	NS	NS	NS	NS
	Fredericksburg	P	NS	NS	NS	NS	NS	NS
Kans:	Wichita[c]	P	9	7	0	0	11	2
	Coffeyville	P	9	8	0	3	10	9
	Dodge City	P	7	8	0	0	15	3
	Falls City	P	5	11	0	5	20	9
	Hays	P	8	9	0	4	13	6
	Kansas City	P	8	9	0	3	7	12
	Topeka	P	8	8	0	1	6	11
	Wichita	P	11	11	0	2	18	8
Ky:	Louisville[c]	P	9	9	0	0	12	3
La:	New Orleans[c]	P	17	14	0	0	29	19
Maine:	Portland[c]	P	9	9	0	0	32	21
Md:	Baltimore[c]	P	10	8	0	0	20	7
Mass:	Boston[c]	P	11	9	0	0	14	18
Mich:	Detroit[c]	P	7	7	0	0	17	11
	Grand Rapids[c]	P	10	9	0	0	11	15
	Bay City	P	5	6	[e]0 (2)	[e]0	17 (2)	13
	Charlevoix	P	8	10	[e]0 (3)	[e]1	20 (3)	15
	Detroit	P	9	7	[e]0	[e]0	0	8
	Grand Rapids	P	7	8	[e]0	[e]0	0	8
	Lansing	P	8	8	[e]0	[e]0	23	15
	Marquette	P	7	10	[e]0 (2)	[e]0	31 (2)	22
	Monroe	P	5	5	[e]0 (2)	[e]0	6 (2)	3
	South Haven	R	6	7	[e]0 (4)	[e]0	15 (4)	8
Minn:	Minneapolis[c]	P	8	9	0	0	26	15
	Bemidji	P	9	8	0	0	19	21
	Duluth	P	13	18	0	0	43	27
	Fergus Falls	P	8	7	0	0	18	21
	Little Falls	P	18	15	0	0	50	30
	Mankato	P	9	6	0	0	13	11
	Minneapolis	P	14	11	0	0	19	17
	Rochester	P	9	8	0	0	15	18
	Worthington	P	NS	4	NS	0	NS	0

See footnotes at end of table.

Table 2. Concentration of radionuclides in milk for July 1971 and 12-month period August 1970 through July 1971—Continued

Sampling location		Type of sample[a]	Radionuclide concentration (pCi/liter)					
			Strontium-90		Iodine-131		Cesium-137	
			Monthly average[b]	12-month average	Monthly average[b]	12-month average	Monthly average[b]	12-month average
UNITED STATES—Continued								
Miss:	Jackson[c]	P	15	12	0	0	18	9
Mo:	Kansas City[c]	P	9	7	0	0	0	3
	St. Louis[c]	P	0	6	0	0	0	4
Mont:	Helena[c]	P	10	6	0	0	14	11
Nebr:	Omaha[c]	P	10	6	0	0	15	3
Nev:	Las Vegas[c]	P	3	2	0	0	16	1
N.H:	Manchester[c]	P	8	9	0	0	25	23
N.J:	Trenton[c]	P	9	9	0	0	17	11
N. Mex:	Albuquerque[c]	P	4	3	0	0	0	0
N.Y:	Buffalo[c]	P	8	7	0	0	12	11
	New York City[c]	P	9	9	0	0	16	17
	Syracuse[c]	P	7	7	0	0	14	10
	Albany	P	8	8	0 (4)	0	[e]0 (4)	[e]0
	Buffalo	P	[e]0	[e]0	0	0	[e]0	[e]0
	Massena	P	NS		NS		NS	
	Newburg	P	5	7	0 (2)	0	[e]0 (2)	[e]0
	New York City	P	11	10	0	0	[e]0	[e]0
	Syracuse	P	11	4	0	0	[e]0 (2)	[e]0
N.C:	Charlotte[c]	P	13	11	0	0	19	13
N. Dak:	Minot[c]	P	11	10	0	0	12	8
Ohio:	Cincinnati[c]	P	6	7	0	0	11	2
	Cleveland[c]	P	9	8	0	0	14	11
Okla:	Oklahoma City[c]	P	7	6	0	0	16	8
Oreg:	Portland[c]	P	6	5	5	0	0	4
	Baker	P	0	2	0	0	0	6
	Coos Bay	P	6	6	0	0	0	9
	Eugene	P	0	3	0	0	0	3
	Medford	P	0	1	0	0	0	7
	Portland composite	P	8	6	0	0	18	6
	Portland local	P	4	4	0	0	17	9
	Redmond	P	NA	3	0	0	0	2
	Tillamook	P	10	7	0	0	22	17
Pa:	Philadelphia[c]	P	10	8	0	0	18	8
	Pittsburgh[c]	P	12	11	0	0	18	14
	Dauphin	P	8	7	0	1	0	12
	Erie	P	NS	7	NS	0	NS	23
	Philadelphia	P	9	8	0	0	18	16
	Pittsburgh	P	10	11	0	1	17	19
R.I:	Providence[c]	P	11	8	0	0	23	19
S.C:	Charleston[c]	P	11	9	0	1	20	15
S. Dak:	Rapid City[c]	P	4	6	0	0	22	5
Tenn:	Chattanooga[c]	P	10	9	0	0	19	9
	Memphis[c]	P	6	7	0	0	12	9
	Chattanooga	P	11	8	0	0	0	15
	Clinton	R	10	9	0 (2)	0	23 (2)	17
	Knoxville	P	8	6	0	0	10	13
	Nashville	P	8	6	0	0	19	12
	Fayetteville	P	11	11	0	0	14	14
	Kingston	R	9	9	0 (2)	0	19 (2)	20
	Pulaski	R	9	9	0 (2)	0	0 (2)	0
Tex:	Austin[c]	P	0	1	0	0	0	0
	Dallas[c]	P	6	6	0	0	12	5
	Amarillo	R	NA		NA		NA	
	Corpus Christi	R	NA		NA		NA	
	El Paso	R	NA		NA		NA	
	Forth Worth	R	NA		NA		NA	
	Harlingen	R	NA		NA		NA	
	Houston	R	NA		NA		NA	
	Lubbock	R	NA		NA		NA	
	Midland	R	NA		NA		NA	
	San Antonio	R	NA		NA		NA	
	Texarkana	R	NA		NA		NA	
	Tyler	R	NA		NA		NA	
	Uvalde	R	NA		NA		NA	
	Wichita Falls	R	NA		NA		NA	
Utah:	Salt Lake City[c]	P	4	5	0	0	15	16
Vt:	Burlington[c]	P	7	6	0	0	15	15
Va:	Norfolk[c]	P	10	9	0	0	14	7
Wash:	Seattle[c]	P	6	5	0	0	20	4
	Spokane[c]	P	7	6	0	0	12	3
	Benton County	R	0	1	0	0	0	2
	Franklin County	R	NS	3	NS	0	NS	5
	Sandpoint, Idaho	R	18	12	0	0	31	23
	Skagit County	R	8	7	0	0	13	12
W. Va:	Charleston[c]	P	12	9	0	0	18	9
Wisc:	Milwaukee[c]	P	7	6	0	0	11	12
Wyo:	Laramie[c]	P	3	5	0	0	0	1
CANADA:								
Alberta:	Calgary	P	NA		NA		NS	
	Edmonton	P	NA		NA		35	23

See footnotes at end of table.

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Table 3. Concentration of radionuclides in milk for July 1971 and 12-month period August 1970 through July 1971—Continued

Sampling location		Type of sample[a]	Radionuclide concentration (pCi/liter)					
			Strontium-90		Iodine-131		Cesium-137	
			Monthly average[b]	12-month average	Monthly average[b]	12-month average	Monthly average[b]	12-month average
CANADA:—Continued								
British Columbia:	Vancouver	P	NA		NA		24	23
Manitoba:	Winnipeg	P	NA		NA		19	24
New Brunswick:	Fredericton	P	NA		NA		21	24
Newfoundland:	St. John's	P	NA		NA		70	32
Nova Scotia:	Halifax	P	NA		NA		30	22
Ontario:	Ottawa	P	NA		NA		16	15
	Sault Ste. Marie	P	NA		NA		39	33
	Thunder Bay	P	NA		NA		53	28
	Toronto	P	NA		NA		12	13
	Windsor	P	NA		NA		24	23
Quebec:	Montreal	P	NA		NA		20	19
	Quebec	P	NA		NA		58	29
Saskatchewan:	Regina	P	NA		NA		26	14
	Saskatoon	P	NA		NA		26	19
CENTRAL AND SOUTH AMERICA:								
Colombia:	Bogota	P	2	1	0	0	0	0
Chile:	Santiago	P	0	0	0	0	13	1
Ecuador:	Guayaquil	P	0	0	0	0	0	0
Jamaica:	Mandeville	P	3	4	0	0	49	48
Venezuela:	Caracas	P	0	0	0	0	0	0
Canal Zone:	Cristobal[e]	P	0	1	0	0	0	9
Puerto Rico:	San Juan[e]	P	2	3	0	0	19	12
PMN network average[f]			7	7	0	0	13	9

[a] P, pasteurized milk.
R, raw milk.

[b] When an individual sampling result was equal to or less than the practical reporting level, a value of "0" was used for averaging. Monthly averages less than the practical reporting level reflect the fact that some but not all of the individual samples making up the average contained levels greater than the practical reporting level. When more than one analysis was made in a monthly period, the number of samples in the monthly average is given in parentheses.

[c] Pasteurized Milk Network station. All other sampling locations are part of the State or National network.

[d] Radionuclide analysis not routinely performed.

[e] The practical reporting levels for these networks differ from the general ones given in the text. Sampling results for the networks were equal to or less than the following practical reporting levels:

Iodine-131: Colorado—25 pCi/liter
Michigan—14 pCi/liter
Oregon—15 pCi/liter

Cesium-137: Colorado—25 pCi/liter
New York—20 pCi/liter
Oregon—15 pCi/liter

Strontium-90: New York—3 pCi/liter

[f] This entry gives the average radionuclides concentrations for the Pasteurized Milk Network stations denoted by footnote [c].
NA, no analysis.
NS, no sample collected.

Reports in perspective, a summary of the guidance provided by the Federal Radiation Council for specific environmental conditions was presented in the December 1970 issue of *Radiological Health Data and Reports.*

Data reporting format

Table 2 presents the integrated results of the international, national, and State networks discussed earlier. Column 1 lists all the stations which are routinely reported to *Radiological Health Data and Reports.* The relationship between the PMN stations and the State stations is shown in figure 2. The first column under each of the reported radionuclides gives the monthly average for the station and the number of samples analyzed in that month in parentheses. When an individual sampling result is equal to or below the practical reporting level for the radionuclide, a value of zero is used for averaging. Monthly averages are calculated using the above convention. Averages which are equal to or less than the practical reporting levels reflect the presence of radioactivity in some of the individual samples greater than the practical reporting level.

The second column under each of the radionuclides reported gives the 12-month average for the station as calculated from the preceding 12 monthly average, giving each monthly average equal weight. Since the daily intake of radioactivity by exposed population groups, averaged over a year, constitutes an appropriate criterion for the case where the FRC radiation protection guides apply, the 12-month average serves as a basis for comparison.

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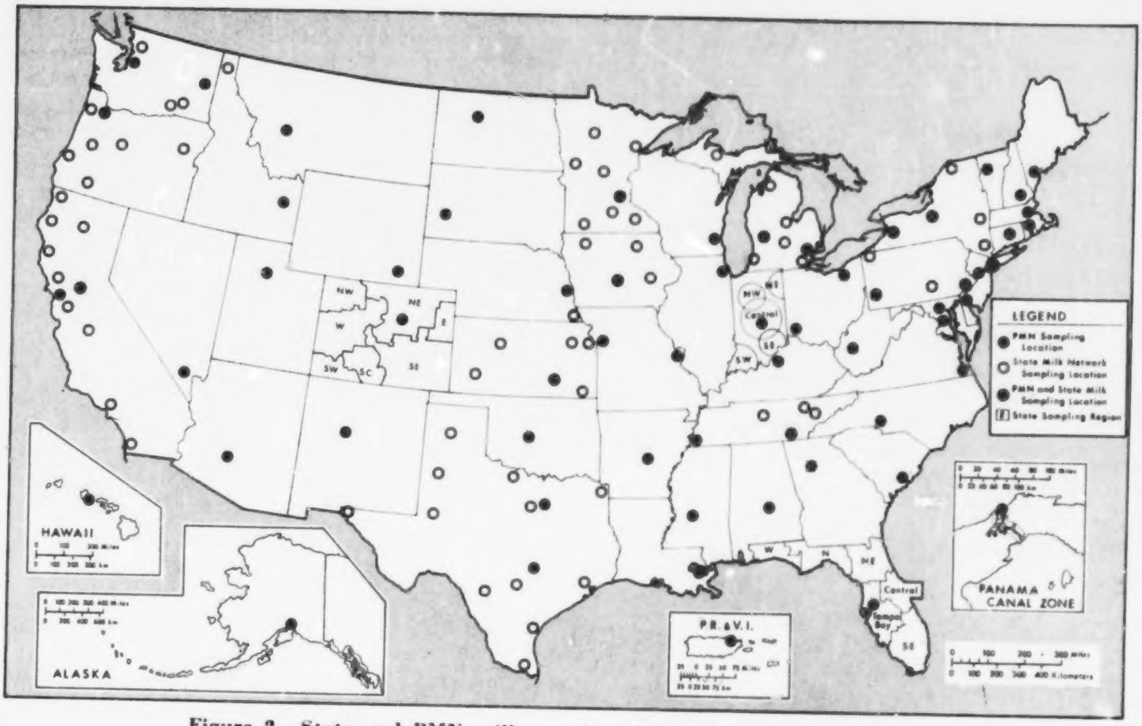
LEGEND
● PMN Sampling Location
○ State Milk Network Sampling Location
● PMN and State Milk Sampling Location
▨ State Sampling Region
HAWAII
ALASKA
P.R. & V.I.
PANAMA CANAL ZONE
NW
NE
W
E
SW
SC
SE
Central
N
Tampa Bay

Figure 2. State and PMN milk sampling locations in the United States

Discussion of current data

In table 2, surveillance results are given for strontium-90, iodine-131, and cesium-137 for July 1971 and the 12-month period, August 1970 to July 1971. Except where noted, the monthly average represents a single sample for the sampling station. Strontium-89 and barium-140 data have been omitted from table 2 since levels at the great majority of the stations for July 1971 were below the respective practical reporting levels. Table 3 gives monthly average for those stations at which strontium-89 was detected.

Iodine-131 results are included in the table, even though they were generally below practical reporting levels. Because of the lower guide levels established by the Federal Radiation Council, levels in milk for this radionuclide are of particular public health interest. In general, the practical reporting level for iodine-131 is nu-

Table 3. Strontium-89 in milk, July 1971

Sampling location		Radionuclide concentration (pCi/liter)
Calif:	Del Norte (State)	7
	Humboldt (State)	6
	Mendocino (State)	5
	San Francisco (PMN)	7
	Sonoma (State)	5
Colo:	Denver (PMN)	10
Idaho:	Idaho Falls (PMN)	6
Iowa:	Des Moines (PMN)	8
Kans:	Dodge City (State)	5
	Falls City (State)	11
	Hays (State)	8
	Topeka (State)	6
Ky:	Louisville (PMN)	6
Minn:	Minneapolis (PMN)	14
Mont:	Helena (PMN)	12
Nebr:	Omaha (PMN)	6
N.Dak:	Minot (PMN)	13
Ohio:	Cincinnati (PMN)	8
Okla:	Oklahoma City (PMN)	8
Oreg:	Portland (PMN)	6
Pa:	Philadelphia (PMN)	6
	Pittsburgh (PMN)	7
S.Dak:	Rapid City (PMN)	7
Tenn:	Clinton (State)	8
	Nashville (State)	6
Utah:	Salt Lake City (PMN)	8
Wash:	Spokane (PMN)	10
Colombia:	Bogota (PAHO)	6
Chile:	Santiago (PAHO)	[a]126
Ecuador:	Guayaquil (PAHO)	6

[a] Attributed to French nuclear tests conducted in the Pacific.

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merically equal to the upper value of Range I (10 pCi/liter) of the FRC radiation protection guide.

Strontium-90 monthly averages ranged from 0 to 18 pCi/liter in the United States for July 1971, and the highest 12-month average was 18 pCi/liter (Duluth, Minn.) representing 9.0 percent of the Federal Radiation Council radiation protection guide. Cesium-137 monthly averages ranged from 0 to 70 pCi/liter in the United States for July 1971, and the highest 12-month average was 72 pCi/liter (Southeast Florida), representing 2.0 percent of the value derived from the recommendations given in the Federal Radiation Council report. Of particular interest are the consistently higher cesium-137 levels that have been observed in Florida (*8*) and Jamaica.

Acknowledgement

Appreciation is expressed to the personnel of the following agencies who provide data for their milk surveillance networks:

Bureau of Radiological Health
Division of Environmental Sanitation
California State Department of Health

Radiation Protection Division
Canadian Department of National
Health and Welfare

Radiological Health Section
Division of Occupational and
Radiological Health
Colorado Department of Health

Radiological Health Services
Division of Medical Services
Connecticut State Department of Health

Radiological and Occupational
Health Section
Department of Health and
Rehabilitative Services
State of Florida

Bureau of Environmental Sanitation
Division of Sanitary Engineering
Indiana State Board of Health

Division of Radiological Health
Environmental Engineering Services
Iowa State Department of Health

Radiation Control Section
Environmental Health Division
Kansas State Department of Health

Radiological Health Services
Division of Occupational Health
Michigan Department of Health

Radiation Control Section
Division of Environmental Health
State of Minnesota Department of Health

Bureau of Radiological Pollution Control
New York State Department of
Environmental Conservation

Environmental Radiation Surveillance Program
Division of Sanitation and Engineering
Oregon State Board of Health

Radiological Health Section
Bureau of Environmental Health
Pennsylvania Department of Public Health

Radiological Health Services
Division of Preventable Diseases
Tennessee Department of Public Health

Division of Occupational Health
Environmental Health Services
Texas State Department of Health

Radiation Control Section
Division of Health
Washington Department of
Social and Health Services

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Food and Diet Surveillance

Efforts are being made by various Federal and State agencies to estimate the dietary intake of selected radionuclides on a continuing basis. These estimates, along with the guidance developed by the Federal Radiation Council, provide a basis for evaluating the significance of radioactivity in foods and diet.

Networks presently in operation and reported routinely include those listed below. These networks provide data useful for developing estimates of nationwide dietary intakes of radionuclides. Programs reported in *Radiological Health Data and Reports* are as follows:

Program	Period reported	Issue
California Diet Study	July–December 1970	November 1971
Carbon-14 in Total Diet and Milk	July–December 1970	May 1971
Connecticut Standard Diet	July–December 1969	December 1970
Radionuclides in Institutional Diet Samples	April–June 1971	November 1971
Strontium-90 in Tri-City Diets	January–December 1969	June 1970

Radionuclides in Institutional Diet Samples, April-June 1971

Environmental Protection Agency and
Food and Drug Administration

The determination of radionuclide concentrations in the diet constitutes an important element of an integrated program of environmental radiological surveillance and assessment. Recognizing that the diet is a potentially significant contributor to total environmental radiation exposures, the Public Health Service initiated its Institutional Diet Sampling Program in 1961. The program is now administered by the Office of Radiation Programs, Environmental Protection Agency with the assistance of the Bureau of Compliance, Food and Drug Administration, Department of Health, Education and Welfare (*1*).

This program estimates the dietary intake of radionuclides in a selected population group, ranging from children to young adults of school age. At present, 25 institutions, distributed geographically as shown in figure 1, are being sampled. Previous results showed that the daily dietary intake of teenage girls and children from 9 to 12 years of age were comparable, but teenage boys consumed 20 percent more food per day (*1-2*). Extrapolating this information, estimates for teenage boys and/or girls can be calculated on the basis of the dietary intake of children.

The sampling procedure is generally the same at each institution. Each sample represents the edible portion of the diet for a full 7-day week, (21 meals plus between-meal snacks) obtained by duplicating the food intake of a different individual daily. Drinking water, which is not included, is also sampled periodically. Each daily sample is kept frozen until the end of the collection period. It is then packed in dry ice and shipped by air to either the Western Environmental Research Laboratory, Las Vegas, Nev; the Eastern Environmental Radiation Laboratory, Mont-

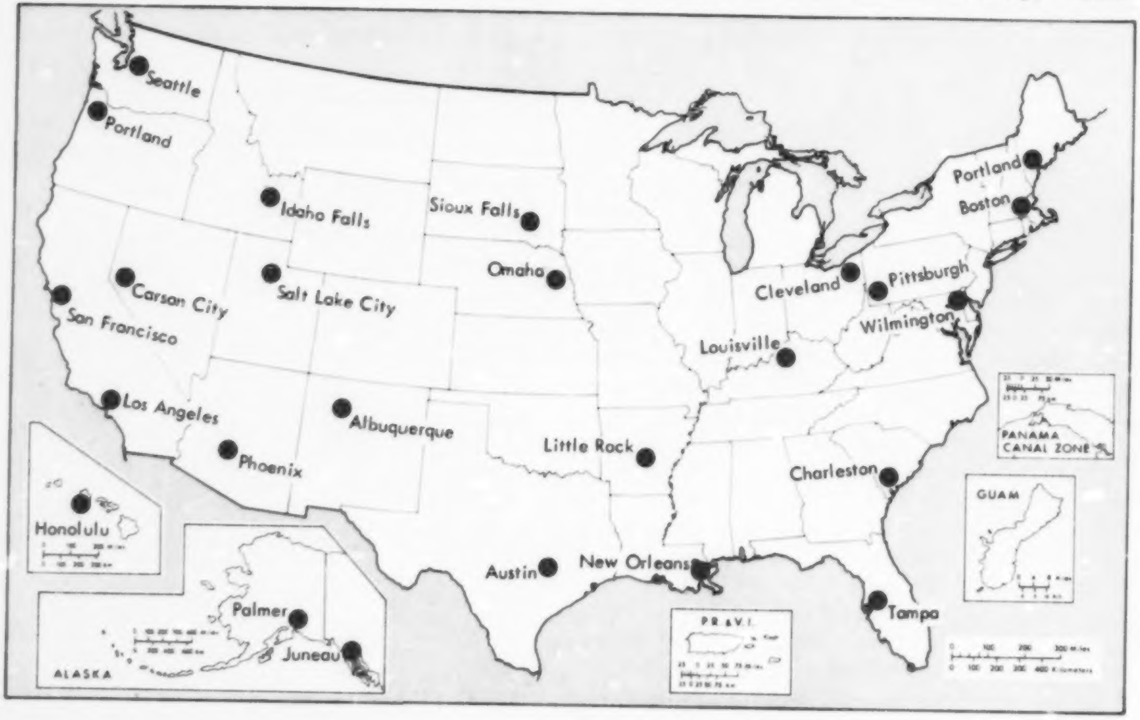
Seattle
Portland
Idaho Falls
Sioux Falls
Portland
Boston
Omaha
Carson City
Salt Lake City
San Francisco
Cleveland
Pittsburgh
Wilmington
Louisville
Los Angeles
Albuquerque
Little Rock
Phoenix
Charleston
PANAMA CANAL ZONE
GUAM
Honolulu
Austin
New Orleans
Tampa
Palmer
Juneau
ALASKA
PR & V.I.

Figure 1. Institutional diet sampling locations as of June 1971

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Table 1. Concentration and intake of stable elements and radionuclides in institutional total diets of children April–June 1971

Location of Institution		Month[a] (1971)	Total weight (kg/day)	Calcium		Potassium		^{90}Sr		^{137}Cs	
				(g/kg)	(g/day)	(g/kg)	(g/day)	(pCi/kg)	(pCi/day)	(pCi/kg)	(pCi/day)
Alaska:	Juneau	April	1.13	0.6	0.7	1.4	1.6	3	3	0	0
	Palmer	April	1.03	.2	.2	1.2	1.2	5	5	13	13
Ariz:	Phoenix	April	1.67	.4	.8	1.6	2.7	0	0	0	0
Ark:	Little Rock	April	1.42	.7	1.0	1.6	2.2	8	11	15	21
Calif:	Los Angeles	April[b]	1.34	.4	.5	1.4	1.8	0	0	0	0
	San Francisco	April[b]	2.00	.6	1.3	1.4	2.8	0	0	0	0
Del:	Wilmington	April	2.14	.6	1.4	1.6	3.5	7	14	11	24
Fla:	Tampa	April	2.47	.5	1.4	1.4	3.5	6	14	23	57
Hawaii:	Honolulu	April	2.17	.5	1.1	1.4	3.0	2	5	12	26
Idaho:	Idaho Falls	April[b]	2.09	.8	1.6	1.5	3.1	12	26	11	23
Ky:	Louisville	April	2.80	.6	1.7	1.6	4.5	6	17	13	36
La:	New Orleans	April[b]	1.48	.6	.9	1.5	2.2	8	12	15	22
Maine:	Portland	April	1.76	.9	1.6	1.6	2.9	17	31	18	32
Mass:	Boston	April	1.97	.7	1.4	1.7	3.4	8	16	14	28
Nebr:	Omaha	April[b]	2.34	1.0	2.2	1.6	3.7	10	24	0	0
Nev:	Carson City	April	1.26	.8	1.0	1.3	1.7	3	4	0	0
N. Mex:	Albuquerque	April	1.06	.9	1.0	1.5	1.6	0	0	0	0
Ohio:	Cleveland	April[b]	1.55	.8	1.3	1.9	3.0	14	21	14	22
Oreg:	Portland	April[b]	1.97	.6	1.2	1.8	3.5	3	7	13	26
Pa:	Pittsburgh	April[b]	2.50	.6	1.5	1.3	3.3	9	22	15	38
S.C:	Charleston	April	2.76	.7	2.0	1.5	4.3	6	16	18	50
S. Dak:	Sioux Falls	April[b]	.94	.8	.7	1.5	1.4	14	13	0	0
Tex:	Austin	April[b]	1.68	.7	1.1	1.5	2.5	4	6	0	0
Utah:	Salt Lake City	April	2.08	.5	1.1	1.0	2.1	0	0	0	0
Wash:	Seattle	April[b]	2.13	.6	1.4	1.4	3.1	0	0	0	0
Institutional average			1.83	.7	1.2	1.5	2.7	6	11	8	17

[a] Quarterly sample usually collected the first month of the quarter.

[b] Food samples were collected from two or more children who were not between the ages of 9 and 12. Note: Strontium-89, iodine-131, and barium-140 were not detected at any station during this period.

gomery, Ala; or the Northeastern Radiological Health Laboratory, Winchester, Mass. A detailed description of sampling and analytical procedures has already been presented in *Radiological Health Data and Reports* (3).

Results

Table 1 shows the analytical results for institutional diet samples collected from all stations during April–June 1971. The stable elements calcium and potassium are reported in g/kg of diet. Where applicable, radionuclide concentrations of these samples reported in pCi/kg of diet are corrected for radioactive decay to the midpoint of the sample collection period. Dietary intakes in g/day or pCi/day were obtained by multiplying the food consumption rate in kg/day by the appropriate concentration values. The average food consumption rate during this period was 1.83 kg/day compared to the network average of 1.86 kg/day observed from 1961 through 1970.

Strontium-90 dietary intake averaged 11 pCi/day during this period. Cesium-137 intake averaged 17 pCi/day. These results fall within Range I as defined by the former Federal Radiation Council (4). Strontium-89, barium-140, and iodine-131 concentrations were below detectable levels.

All concentrations less than or equal to the appropriate minimum detectable level have been reported as zero. The minimum detectable concentration is defined as the measured concentration equal to the 2 standard-deviation analytical error. Accordingly, the minimum detectable limits are strontium-89, 5 pCi/kg; strontium-90, 2 pCi/kg; iodine-131, 10 pCi/kg; barium-140, 10 pCi/kg; cesium-137, 10 pCi/kg.

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
April–June 1970	January 1971
July–September 1970	February 1971
October–December 1970	May 1971
January–March 1971	September 1971

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Estimated Daily Intake of Radionuclides in California Diets July-December 1970

Bureau of Radiological Health
California State Department of Public Health

Since January 1964, the Bureau of Radiological Health, California State Department of Public Health, has made estimates of radionuclide levels in the diets of Californians (*1*).

Recognizing that a "standard" or "typical" diet does not exist due to variations in individual tastes, an effort was made to select a diet which was reasonably representative of the food consumed in a given area. This objective was met by utilizing the "house" diet of a hospital in each of the 19 geographic areas of interest (figure 1).

Hospitals were chosen as the source of diet samples under the hypothesis that their diets are as "reasonably representative" as any other. General hospitals exist in each of the 19 selected geographic areas and operate with trained dietitians. There is good reason to believe that hospitals utilize foods which are marketed in their respective communities. Also, working relations for entry into hospitals existed through the State Bureau of Nutrition and Hospitals.

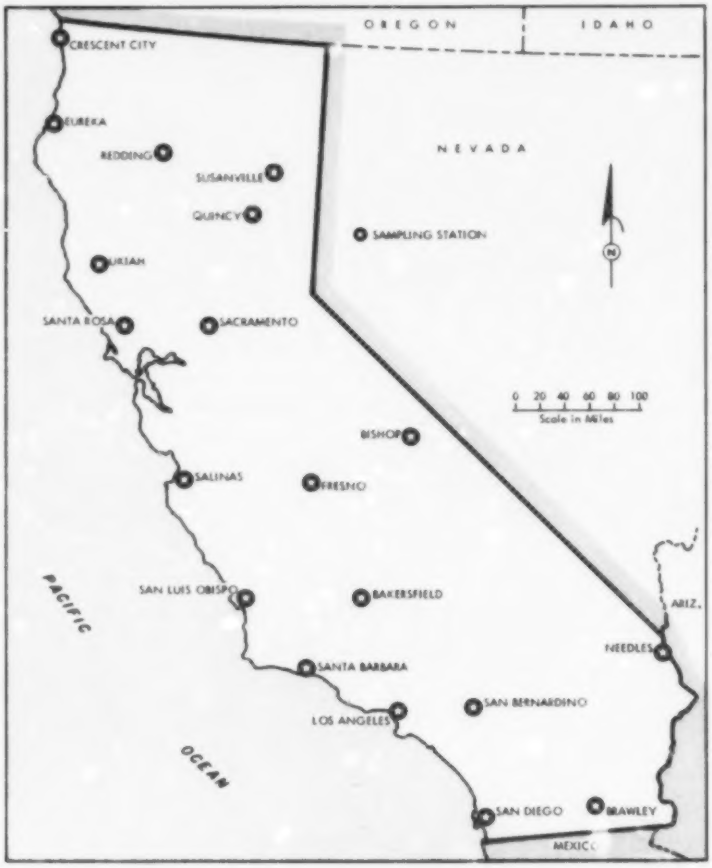
OREGON
IDAHO
NEVADA
CRESCENT CITY
EUREKA
REDDING
SUSANVILLE
QUINCY
UKIAH
SANTA ROSA
SACRAMENTO
SAMPLING STATION
N
0 20 40 60 80 100
Scale in Miles
BISHOP
SALINAS
FRESNO
PACIFIC
SAN LUIS OBISPO
BAKERSFIELD
ARIZ.
NEEDLES
SANTA BARBARA
SAN BERNARDINO
LOS ANGELES
OCEAN
SAN DIEGO
BRAWLEY
MEXICO

Figure 1. California diet sampling stations

Table 1. Estimated daily intakes of radionuclides in California diets,[a] July–September 1970

City	Consumption (kg/capita-day)[b]	Intake (pCi/capita-day)							Intake (g/capita-day)		
		^{89}Sr	^{90}Sr	^{226}Ra	^{137}Cs	^{95}Zr	^{54}Mn	$^{141-144}$Ce	K[c]	Na	Ca
Bakersfield	1.7	1	5	1.1	0	4	15	0	2.5	3.8	0.7
Bishop	1.9	0	6	1.5	2	2	13	2	2.8	2.7	.8
Brawley	2.2	7	9	1.9	0	8	13	0	3.1	4.3	1.3
Crescent City	2.0	6	12	1.5	10	1	16	0	2.9	4.1	.8
Eureka	2.2	3	6	.8	0	5	17	0	2.6	3.9	.7
Fresno	2.1	0	6	1.3	0	5	20	7	3.4	3.1	1.1
Los Angeles	2.3	0	6	1.0	2	4	17	0	3.2	4.0	.8
Needles	2.3	0	8	.4	0	8	13	0	2.9	3.3	1.1
Quincy	2.6	0	7	.8	0	4	14	0	4.3	4.4	1.2
Redding	2.5	4	7	1.1	2	4	17	0	4.1	3.4	1.1
Sacramento	2.7	4	4	1.3	0	6	27	0	3.1	4.4	1.2
Salinas	2.5	0	6	1.0	0	7	15	0	3.4	6.9	.5
San Bernardino	2.0	0	4	.7	0	4	18	0	3.2	3.8	1.0
San Diego	1.8	0	6	1.0	0	3	14	0	2.8	3.0	.8
San Luis Obispo	2.3	1	6	1.6	2	3	20	0	3.5	4.6	1.2
Santa Barbara	2.3	0	7	1.4	1	5	15	0	3.2	2.9	1.3
Santa Rosa	1.8	5	2	1.4	0	3	13	6	2.4	3.7	.9
Susanville	1.8	1	6	.7	5	4	13	7	2.4	2.5	.8
Ukiah	2.0	0	7	.4	0	5	15	7	3.1	3.6	1.3

[a] Based on analyses of Hospital Standard Diets located in listed cities.
[b] Kilograms of food per person per day in this diet.
[c] Natural potassium contains 0.0119 percent of radioactive potassium-40.

Sampling procedure

In general, the sampling procedure is the same at each hospital. Samples are collected every 2 months at each facility. Each sample represents the edible portion of a regular meal (the standard diet) for a full 7-day week (21 consecutive meals.)

After each sample is collected, it is suitably preserved and shipped to the Sanitation and Radiation Laboratory of the State Department of Public Health. Accompanying each sample is a record prepared by the dietitians indicating the types and quantities of food included.

Analytical procedures

After weighing at the laboratory, each sample is homogenized and analyzed for gamma-ray emitters, then dried and ashed prior to analysis for strontium-89, strontium-90, radium-226, and stable calcium, strontium, and sodium.

Data and discussion

The resultant estimates of daily intake of radionuclides in the California diets are given in table 1 (July–September 1970) and table 2 (October–December 1970).

Table 2. Estimated daily intakes of radionuclides in California diets,[a] October–December 1970

City	Consumption (kg/capita-day)[b]	Intake (pCi/capita-day)							Intake (g/capita-day)		
		^{89}Sr	^{90}Sr	^{226}Ra	^{137}Cs	^{95}Zr	^{54}Mn	$^{141-144}$Ce	K[c]	Na	Ca
Bakersfield	1.9	0	8	1.1	2	3	15	0	3.0	4.6	1.1
Bishop	1.7	0	4	1.1	0	6	12	0	2.4	2.9	.7
Brawley	1.6	4	11	1.8	0	3	12	10	2.9	4.2	.7
Crescent City	2.1	0	12	1.1	1	6	16	0	3.0	4.2	.8
Eureka	2.1	0	6	1.1	1	5	14	14	2.6	3.9	.6
Fresno	2.2	0	7	.9	0	4	18	0	3.3	3.3	1.0
Los Angeles	2.0	1	5	1.5	2	4	16	0	3.0	4.0	.6
Needles	2.2	2	4	1.2	4	4	16	0	2.4	3.0	.8
Quincy	2.3	3	5	1.2	1	2	18	16	3.0	3.0	.7
Redding	2.4	1	8	1.7	2	7	17	0	3.3	3.5	1.4
Sacramento	2.6	3	6	2.0	0	8	16	0	3.5	4.5	1.2
Salinas	2.4	5	5	2.1	3	6	16	0	3.5	6.8	.9
San Bernardino	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
San Diego	2.2	2	6	1.2	5	6	16	0	3.3	3.3	1.0
San Luis Obispo	2.2	0	4	1.2	0	9	17	0	3.3	4.0	1.0
Santa Barbara	2.8	0	5	1.2	4	8	15	0	2.8	3.8	1.1
Santa Rosa	1.9	3	7	2.2	7	3	14	0	3.5	4.4	1.3
Susanville	1.7	2	4	.4	3	3	10	0	2.1	2.6	.8
Ukiah	2.1	4	6	1.2	0	4	16	0	3.1	4.0	1.4

[a] Based on analyses of Hospital Standard Diets located in listed cities.
[b] Kilograms of food per person per day in this diet.
[c] Natural potassium contains 0.0119 percent of radioactive potassium-40.
NS, no sample.

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It should be noted that levels of radioactivity were observed to be far below those levels for which consideration should be given to protective health action.

A summary of strontium-90 and cesium-137 intake trends in California diets from January 1964 through December 1970 is given in figures 2 and 3.

REFERENCES

(1) STATE OF CALIFORNIA DEPARTMENT OF PUBLIC HEALTH, BUREAU OF RADIOLOGICAL HEALTH. Radiol Health News 4:4 (October 1965). 2151 Berkeley Way, Berkeley, Calif. 94704.

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
April–December 1969 and January–June 1970	November 1970

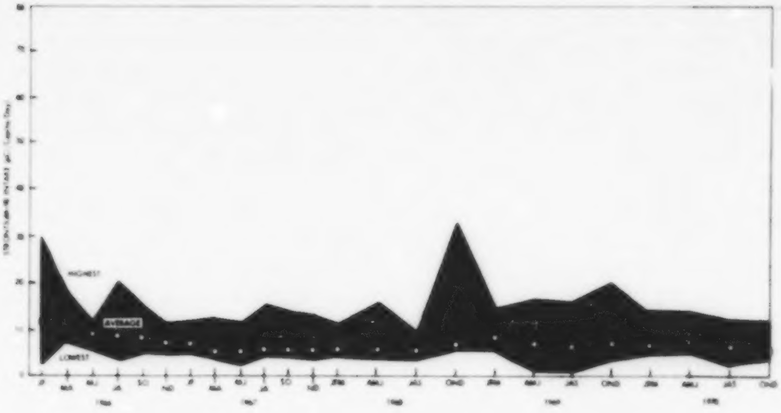

Figure 2. Averages and ranges of daily strontium-90 intake in California diets

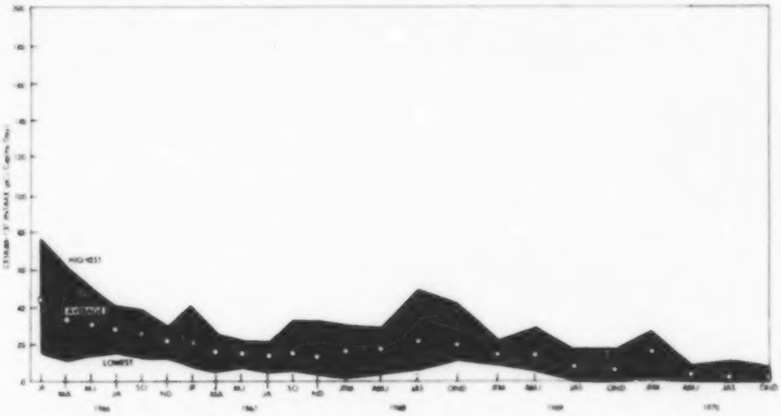

Figure 3. Averages and ranges of daily cesium-137 intake in California diets

Strontium-90 in Tri-City Diets, January-December 1970

Health and Safety Laboratory
U.S. Atomic Energy Commission

Estimates of the average intake of strontium-90 by New York City, Chicago, and San Francisco residents have been made by the Health and Safety Laboratory (*HASL*). These estimates were made by using measurements of the strontium-90 content of a large variety of foods purchased at the cities every 3 months and statistics on the average consumption of each food compiled by the U.S. Department of Agriculture in their 1955 Household Diet Survey (*1*). A detailed description of the aims and methods of the *HASL* diet sampling program along with a summary of the results obtained during the first 3 years of operation (1960–1963) was published earlier (*2*).

In 1968, two changes were made in the program. The first change was the suspension of the collection and analysis of foods purchased in Chicago. Previous experience had shown the levels of strontium-90 in the Chicago diet to be consistently between those of New York City and San Francisco. Thus, reasonable estimates of the dietary intake of strontium-90 in Chicago at any time can be made from the analyses of foods purchased in New York City and San Francisco.

The second change, revision of the estimates of the annual consumption of different diet components, was made because new information became available. This new information on the composition of the diet appeared in a preliminary report of the U.S. Department of Agriculture in their 1965 Household Diet Survey (*3*). The changes in the composition of the diet from 1955 to 1965 are not very great, and the estimates of strontium-90 intake made using statistics from

Table 1. Average dietary consumption and strontium-90 intake in Tri-City diet, January–March 1970

Food category	Diet (kg/a)	Calcium (g/a)	New York City February 1970		San Francisco March 1970	
			Strontium-90		Strontium-90	
			(pCi/kg)	(pCi/a)	(pCi/kg)	(pCi/a)
Dairy products	200	216.0	7.5	1,500	2.5	504
Fresh fruit	59	9.4	7.8	462	1.7	103
Fresh vegetables	48	18.7	10.1	486	3.9	186
Root vegetables	10	3.8	.3	3	4.3	43
Potatoes	38	3.8	10.3	391	1.3	50
Macaroni	3	.6	4.9	15	3.6	11
Rice	3	1.1	2.4	7	1.8	5
Fruit juices	28	2.5	3.1	88	1.9	54
Canned vegetables	22	4.4	10.9	240	1.5	32
Canned fruit	11	.6	1.3	14	1.0	11
Dried beans	3	2.1	50.5	151	21.8	66
Flour	34	6.5	8.7	296	4.1	140
Bakery products	44	53.7	4.5	198	3.2	139
Whole grain products	11	10.3	13.6	150	5.5	61
Fresh fish	8	7.6	.2	2	.2	1
Shellfish	1	1.6	.8	1	.6	1
Poultry	20	6.0	1.6	33	1.6	32
Meat	79	12.6	1.2	98	.4	30
Eggs	15	8.7	1.8	26	2.0	29
Annual intake (pCi/a)		370		4,161		1,498
Daily intake (pCi/g Ca)				11.2		4.0

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[1] Data from Fallout Program Quarterly Summary Report, HASL 227, 237, 239, 242. Available from the Clearinghouse for Federal Scientific and Technical Information, CFSTI, 5285 Port Royal Road, Springfield, Va. 22151.

Table 2. Average dietary consumption and strontium-90 intake in Tri-City diet, April–June 1970

Food category	Diet (kg/a)	Calcium (g/a)	New York City May 1970		San Francisco June 1970	
			Strontium-90		Strontium-90	
			(pCi/kg)	(pCi/a)	(pCi/kg)	(pCi/a)
Dairy products	200	216.0	10.5	2,110	2.0	406
Fresh fruit	59	9.4	12.5	736	1.8	107
Fresh vegetables	48	18.7	11.8	568	3.1	146
Root vegetables	10	3.8	8.6	86	4.2	42
Potatoes	38	3.8	8.7	331	1.3	49
Macaroni	3	.6	4.4	13	4.4	13
Rice	3	1.1	1.6	5	2.3	7
Fruit juices	28	2.5	3.4	96	2.1	60
Canned vegetables	22	4.4	6.4	140	2.6	57
Canned fruit	11	.6	1.4	15	1.1	13
Dried beans	3	2.1	3.9	12	15.7	47
Flour	34	6.5	7.1	242	4.0	136
Bakery products	44	53.7	4.9	217	4.3	189
Whole grain products	11	10.3	11.6	128	8.6	94
Fresh fish	8	7.6	.6	5	1.6	13
Shellfish	1	1.6	1.4	1	.6	1
Poultry	20	6.0	1.9	38	.7	15
Meat	79	12.6	1.1	84	.6	49
Eggs	15	8.7	2.3	34	2.1	31
Annual intake (pCi/a)		370		4,861		1,475
Daily intake (pCi/g Ca)				13.1		4.0

either diet survey are not too different. Estimates of the intakes of other nuclides, however, may be affected to a greater degree. The new estimates of the consumption have therefore been used to calculate the intakes of calcium and strontium-90 for 1970 in New York City and San Francisco.

Results for January-December 1970 are presented in tables 1 through 4. The variation with time of the daily intake of strontium-90 in the three cities is plotted in figure 1.

Table 3. Average dietary consumption and strontium-90 intake in Tri-City diet, July–September 1970

Food category	Diet (kg/a)	Calcium (g/a)	New York City August 1970		San Francisco September 1970	
			Strontium-90		Strontium-90	
			(pCi/kg)	(pCi/a)	(pCi/kg)	(pCi/a)
Dairy products	200	216.0	9.0	1,810	2.1	420
Fresh fruit	59	9.4	2.2	128	3.1	185
Fresh vegetables	48	18.7	10.2	491	2.1	102
Root vegetables	10	3.8	4.3	43	4.4	44
Potatoes	38	3.8	4.5	172	3.1	118
Macaroni	3	.6	4.7	14	3.7	11
Rice	3	1.1	2.0	6	2.1	6
Fruit juices	28	2.5	3.6	102	1.8	49
Canned vegetables	22	4.4	12.7	279	2.0	44
Canned fruit	11	.6	1.4	15	.8	9
Dried beans	3	2.1	16.2	49	47.1	141
Flour	34	6.5	6.6	223	4.4	151
Bakery products	44	53.7	6.2	274	4.3	190
Whole grain products	11	10.3	15.1	166	7.1	78
Fresh fish	8	7.6	.3	2	.2	2
Shellfish	1	1.6	[a]1.4	[a]1	.6	1
Poultry	20	6.0	.8	15	1.8	35
Meat	79	12.6	[a]1.1	[a]84	.3	23
Eggs	15	8.7	2.3	35	1.4	22
Annual intake (pCi/a)		370		3,909		1,631
Daily intake (pCi/g Ca)				10.6		4.4

[a] The meat and shellfish samples for New York City were lost during analyses. Values reported for second quarter 1970 were used.

Table 4. Average dietary consumption and strontium-90 intake in Tri-City diet, October–December 1970

Food category	Diet (kg/a)	Calcium (g/a)	New York City November 1970 Strontium-90 (pCi/kg)	New York City November 1970 Strontium-90 (pCi/a)	San Francisco December 1970 Strontium-90 (pCi/kg)	San Francisco December 1970 Strontium-90 (pCi/a)
Dairy products	200	216.0	7.8	1,550	2.0	396
Fresh fruit	59	9.4	13.9	818	2.5	148
Fresh vegetables	48	18.7	16.9	812	3.5	168
Root vegetables	10	3.8	6.8	68	9.9	99
Potatoes	38	3.8	6.8	261	2.4	92
Macaroni	3	.6	5.2	16	4.1	12
Rice	3	1.1	1.8	6	1.5	4
Fruit juices	28	2.5	4.5	126	2.5	71
Canned vegetables	22	4.4	9.4	208	2.3	51
Canned fruit	11	.6	1.6	17	.8	8
Dried beans	3	2.1	19.6	59	7.5	22
Flour	34	6.5	8.2	280	4.4	150
Bakery products	44	53.7	6.6	290	3.4	152
Whole grain products	11	10.3	13.8	152	10.9	120
Fresh fish	8	7.6	.5	4	.4	4
Shellfish	1	1.6	.7	<1	.6	<1
Poultry	20	6.0	1.0	19	1.1	22
Meat	79	12.6	.7	55	.4	30
Eggs	15	8.7	2.0	30	1.5	23
Annual intake (pCi/a)		370		4,772		1,573
Daily intake (pCi/g Ca)				12.9		4.3

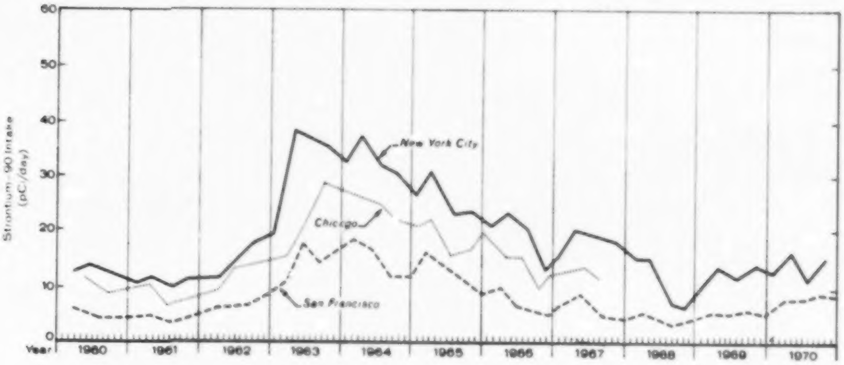

Figure 1. Daily intake of strontium-90 in Tri-City diets, March 1960–December 1970

REFERENCES

(1) U.S. DEPARTMENT OF AGRICULTURE. Food consumption of households in the United States, household food consumption survey, Report No. 1 (1955). Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (December 1956).

(2) RIVERA, J. and J. H. Harley. HASL contributions to the study of fallout in food chains, HASL-137. Office of Technical Services, U.S. Atomic Energy Commission, New York, N.Y. (July 1, 1964).

(3) U.S. DEPARTMENT OF AGRICULTURE. Food consumption of households in the United States, spring 1965. A Preliminary Report, USDA, ARS 62-16 (August 1967).

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
July–December 1968	December 1969
January–December 1969	June 1970

SECTION II. WATER

The Environmental Protection Agency and other Federal, State, and local agencies operate extensive water quality sampling and analysis programs for surface, ground, and treated water. Most of these programs include determinations of gross beta and gross alpha radioactivity and specific radionuclides.

Although the determination of the total radionuclide intake from all sources is of primary importance, a measure of the public health importance of radioactivity levels in water can be obtained by comparison of the observed values with the Public Health Service Drinking Water Standards (*1*). These standards, based on consideration of Federal Radiation Council (FRC) recommendations (*2–4*) set the limits for approval of a drinking water supply containing radium-226 and strontium-90 at 3 pCi/liter and 10 pCi/liter, respectively. Higher concentrations may be acceptable if the total intake of radioactivity from all sources remains within the guides recommended by FRC for control action. In the known absence[1] of strontium-90 and alpha-particle emitters, the limit is 1,000 pCi/liter gross beta radioactivity, except when additional analysis indicates that concentrations of radionuclides are not likely to cause exposures greater than the limits indicated by the Radiation Protection Guides. Surveillance data from a number of Federal and State programs are published periodically to show current and long-range trends. Water sampling activities reported in *Radiological Health Data and Reports* are listed below.

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[1] Absence is taken to mean a negligibly small fraction of the specific limits of 3 pCi/liter and 10 pCi/liter for unidentified alpha-particle emitters and strontium-90, respectively.

Water sampling program	Period reported	Issue
California	January–December 1969	October 1971
Gross Radioactivity in Surface Waters of the United States	February 1971	October 1971
Interstate Carrier Drinking Water	1970	July 1971
Kansas	January–December 1969	September 1970
Minnesota	January–June 1970	November 1971
North Carolina	January–December 1967	May 1969
New York	January–December 1969 and January–June 1970	September 1971
Radiostrontium in Tap Water, *HASL*	January–June 1970	April 1971
Tritium in Community Water Supplies	1969	December 1970
Tritium Surveillance System	April–June 1971	November 1971
Washington	July 1968–June 1969	February 1971

REFERENCES

(*1*) U.S. PUBLIC HEALTH SERVICE. Drinking water standards, revised 1962, PHS Publication No. 956. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (March 1963).

(*2*) FEDERAL RADIATION COUNCIL. Radiation Protection Guidance for Federal Agencies, Memorandum for the President, September 1961. Reprint from the Federal Register of September 26, 1961.

(*3*) FEDERAL RADIATION COUNCIL. Background material for the development of Radiation Protection Standards, Report No. 1. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (May 1960).

(*4*) FEDERAL RADIATION COUNCIL. Background material for the development of Radiation Protection Standards, Report No. 2. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (September 1961).

Gross Radioactivity in Surface Waters of the United States, March 1971

Office of Water Programs
Environmental Protection Agency

The monitoring of gross radioactivity in surface waters of the United States was initiated in 1957, as part of the Water Pollution Surveillance System (formerly the National Water Quality Network) of the U.S. Public Health Service. Currently, the program is operated by the Environmental Protection Agency, Office of Water Programs. Regional offices of the Environmental Protection Agency are responsible for the collection of samples and entering of the analytical findings into STORET, the Office of Water Programs' computerized data storage and retrieval system. Radioactivity analyses are performed in the centralized radioactivity laboratories of the Office of Water Programs (Cincinnati, Ohio).

The regular reporting of gross radioactivity data in *Radiological Health Data and Reports* was terminated with the publication of data for October 1968 (April 1969 issue). With the publication of data for January 1971, it is intended to reinitiate this activity as a monthly report series. The unpublished data for the time interval of November 1968 through December 1970 will be the subject of a future summary article.

Table 1 presents the gross alpha and beta results for samples collected from 24 rivers during March 1971. The analytical procedures used for determining gross alpha and gross beta radioactivity are described in the 13th Edition of "Standard Methods for the Examination of

Table 1. Gross radioactivity in U.S. surface waters, March 1971[a]

River and station	Number of grab samples	Gross alpha radioactivity (pCi/liter)		Gross beta radioactivity (pCi/liter)	
		Suspended solids	Dissolved solids	Suspended solids	Dissolved solids
Allegheny River:					
Pittsburgh, Pa	1	2	1	3	6
	1	<0.2	<0.2	1	7
Beaver River:					
New Brighton, Pa	1	< .2	1	1	10
Big Sandy River:					
Wayne County, Ky	1	< .2	< .2	1	6
Big Sioux River:					
Sioux Falls, S. Dak	1	< .2	2	3	40
Cheyenne River:					
Edgemont, S. Dak:	1	< .2	9	2	13
Clinch River:					
Kingston, Tenn.	3	(< .2, < .2) < .2	(< .2, < .2) < .2	(1, 1) 1	(4, 9) 6.7
Cuyahoga River:					
Cleveland, Ohio	1	1	2	3	11
Great Lakes, Lake Erie:					
Buffalo, N.Y	1	< .2	< .2	2	10
Great Miami River:					
Lost Bridge, Ohio	1	3	5	6	6
Elizabethtown, Ohio:					
American Material Bridge	1	2	2	8	8
Liberty Fairfield, Ohio	1	3	2	18	11
Sellars Road, Ohio	1	2	4	7	5
Eldean Mills, Ohio	1	3	2	2	9
Guyandotte River:					
Guyandotte, W. Va	1	< .2	< .2	1	7
Kanawha River:					
Mason County, W. Va	1	< .2	< .2	1	5
Winfield Dam, W. Va	1	1	< .2	2	4
Kentucky River:					
Dam No. 1, Ky	1	2	< .2	2	2

Table 1. Gross radioactivity in U.S. surface waters, March 1971[a]—continued

River and station	Number of grab samples	Gross alpha radioactivity (pCi/liter)		Gross beta radioactivity (pCi/liter)	
		Suspended solids	Dissolved solids	Suspended solids	Dissolved solids
Licking River:					
12th St. Bridge, Ky	1	3	< .2	<1	9
Little Miami:					
Cincinnati, Ohio	1	12	< .2	15	8
Maumee River:					
Toledo, Ohio	1	1	1	<1	14
Mississippi River:					
Burlington, Iowa	1	1	2	4	12
Missouri River:					
Yankton, S. Dak	1	< .2	4	<1	9
St. Joseph, Mo	1	3	4	20	21
St. Louis, Mo	1	13	1	34	11
Monongahela River:					
Pittsburgh, Pa	1 1	< .2 < .2	< .2 < .2	2 <1	9 5
Muskingum River:					
Lock and Dam No. 2, W. Va	1	2	3	6	8
North Platte River:					
Henry, Nebr	1	<2	28	<1	45
Ohio River:					
New Martinsville, W. Va	1	1	< .2	1	6
Marietta, Ohio	1	< .2	< .2	2	5
Old Lock No. 19, W. Va	1	< .2	< .2	1	5
Addison, Ohio	1	2	1	3	11
Kyger Creek, W. Va	1	1	< .2	2	6
Boyd County, Ky	1	1	1	1	5
Meldahl Dam, Ohio	1	2	1	4	3
Madison, Ind	1	3	< .2	<1	2
Markland Dam, Ohio	1	3	< .2	1	3
Anderson Ferry, Ohio	1	2	< .2	14	6
Miami Fort, Ohio	1	2	1	4	2
Cincinnati, Ohio	3	(< .2, [illegible]) < [illegible]	(< .2, 1) < .5	(1, 11) 6.7	(4, 5) 4.3
Maysville, Ky	1	10	< .2	13	4
Portsmouth, Ohio	1	1	< .2	7	<1
Greenup Dam, Ky	1	1	< .2	1	4
Ironton, Ohio	1	1	< .2	8	5
Warwood, W. Va	1	1	1	4	6
Hancock, W. Va	1	1	< .2	1	6
South Heights, Pa	1	1	< .2	<1	10
Roanoke River:					
John Kerr Dam, Va	5	(< .2, 1) < .5	(< .2, 1) < .4	(< .2, 4) <1.8	(3, 4) 3.6
St. Lawrence River:					
Massena, N.Y	2	(< .2, < .2) < .2	(< .2, 1) < .6	(< .2, 1) < .6	(6, 7) 6.5
White Water Bridge:					
Suspension Bridge, Ohio	1	1	2	8	9

[a] When more than one sample is analyzed, the minimum and maximum values are in parentheses.

Water and Wastewater" (*1*). Results are reported for the date of counting and are not corrected to the date of collection. The sensitivity in counting is that defined by the National Bureau of Standards, Handbook 86 (*2*) and is calculated to be <0.2 pCi/liter for gross alpha and <1 pCi/liter for gross beta measurements.

REFERENCES

(*1*) AMERICAN PUBLIC HEALTH ASSOCIATION; AMERICAN WATER WORKS ASSOCIATION AND WATER POLLUTION CONTROL FEDERATION. Standard methods for the examination of water and wastewater, 13th Edition. New York, N.Y. (1971).

(*2*) U.S. DEPARTMENT OF COMMERCE. Radioactivity, Recommendations of the International Commission on Radiological Units and Measurements, NBS Handbook 86 (November 29, 1963).

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Radioactivity in Minnesota Municipal Water Supplies[1] January-June 1970

Division of Environmental Sanitation
Minnesota Department of Health

The analysis of various Minnesota waters for radioactivity was initiated in 1956 as part of the Minnesota Water Pollution Control Program. This program was expanded in 1958 to include most of the municipal surface water supplies in the State, as well as selected lakes throughout the State.

As many as 25 surface streams and lakes involving 74 stations have been sampled. At present, nine surface streams and lakes used as municipal water supplies are sampled routinely (figure 1). "Grab" samples of raw and treated water are collected weekly at Hallock, East Grand Forks, Eveleth, Fairmont, and St. Paul. Beginning in November 1969, weekly samples from these stations were composited and analyzed on a monthly basis. Monthly samples are taken at Crookston, International Falls and St. Cloud. Minneapolis tap water is analyzed weekly. No raw water is collected from the Minneapolis supply.

The samples are forwarded to the Division's laboratory, where they are analyzed for gross alpha and beta radioactivity. A 500-ml sample of water is evaporated into a 2-inch aluminum milk bottle lid planchet and counted in an internal-proportional gas flow counter. Counter standardization is accomplished by adding known

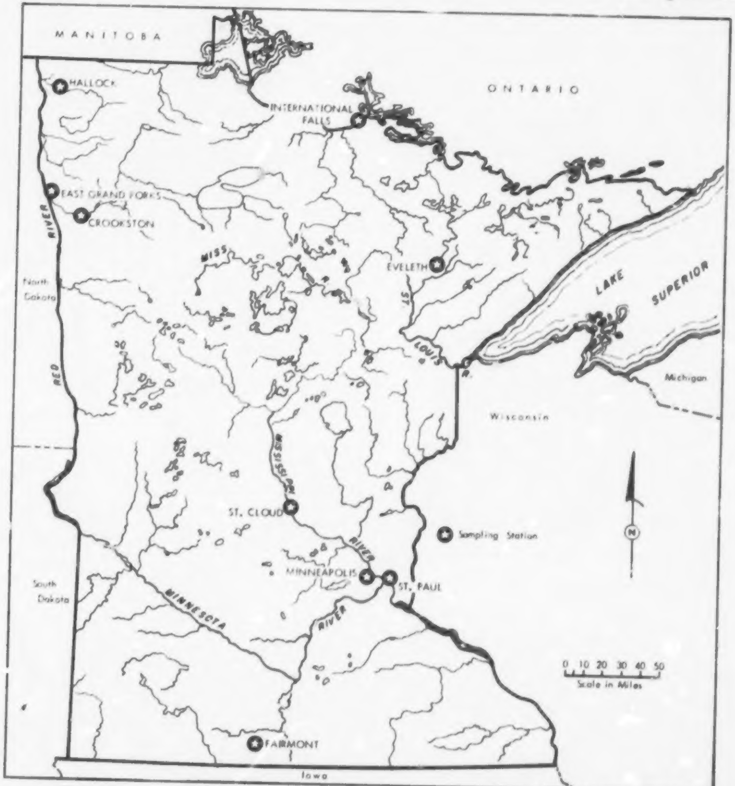
MANITOBA
ONTARIO
HALLOCK
INTERNATIONAL FALLS
EAST GRAND FORKS
CROOKSTON
RED RIVER
North Dakota
MISS.
EVELETH
ST. LOUIS R.
LAKE SUPERIOR
Michigan
Wisconsin
MISSISSIPPI RIVER
ST. CLOUD
Sampling Station
N
MINNEAPOLIS
ST. PAUL
South Dakota
MINNESOTA RIVER
0 10 20 30 40 50
Scale in Miles
FAIRMONT
Iowa

Figure 1. Minnesota surface water sampling locations

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[1] Data and information from "Survey of Environmental Radioactivity, January-June 1970," Publication No. C00-651-83. State of Minnesota Department of Public Health, University Campus, Minneapolis, Minn. 55440.

Table 1. Average gross beta radioactivity in Minnesota raw and treated water supplies January–June 1970

Town and water source	Type of water	Average concentrations (pCi/liter)					
		Jan	Feb	Mar	Apr	May	June
Crookston, Red Lake River	Raw	22	17	[a]16	(a)	27	28
	Treated	17	18	[a]19	(a)	14	19
East Grand Forks, Red Lake River	Raw	15	18	16	19	21	25
	Treated	10	8	11	9	11	11
Eveleth, St. Mary's Lake	Raw	12	11	10	11	12	10
	Treated	11	10	11	12	14	12
Fairmont, Budd Lake	Raw	11	11	8	13	13	11
	Treated	5	4	4	5	7	6
Hallock, Two Rivers South Fork	Raw	7	19	7	20	32	30
	Treated	20	5	6	11	15	13
International Falls, Rainy River	Raw	8	11	5	11	7	12
	Treated	14	11	6	NA	NA	11
Minneapolis tap water	Treated	5	5	2	6	7	5
St. Cloud, Mississippi River	Raw	[b] <2	(b)	[a]10	(a)	13	14
	Treated	[b]8	(b)	[a]4	(a)	3	6
St. Paul, Vadnais Chain of Lakes	Raw	6	8	8	10	25	11
	Treated	8	3	3	3	3	7

[a] March–April composite.
[b] January–February composite.
NA, no analysis.

Table 2. Average gross alpha radioactivity in Minnesota raw and treated water supplies, January–June 1970

Town and water source	Type of water	Average concentrations (pCi/liter)					
		Jan	Feb	Mar	Apr	May	June
Crookston, Red Lake River	Raw	<2	<1	[a] <2	(a)	6	6
	Treated	<2	<1	<1	<3	<3	<3
East Grand Forks, Red Lake River	Raw	<2	<2	<2	<4	<2	<3
	Treated	<2	<1	<1	<2	<1	<2
Eveleth, St. Mary's Lake	Raw	<1	<1	<1	<2	<1	<1
	Treated	<1	<1	<1	<2	<1	<1
Fairmont, Budd Lake	Raw	<3	4	<4	<4	6	<3
	Treated	<2	<2	<2	<2	<2	<2
Hallock, Two Rivers South Fork	Raw	<2	<3	<1	<4	3	<4
	Treated	<5	<2	<2	<2	<1	<2
International Falls, Rainy River	Raw	<1	<1	<1	<1	<1	1
	Treated	1	<1	<1	<1	NA	<1
Minneapolis tap water	Treated	<1	<1	<1	<1	<1	<2
St. Cloud, Mississippi River	Raw	[b] <1	(b)	[a] <1	(a)	<1	<3
	Treated	[b] <2	(b)	[a] <1	(a)	<1	<1
St. Paul, Vadnais Chain of Lakes	Raw	<2	<2	<3	<3	<1	<2
	Treated	<2	<1	<1	<1	<1	<3

[a] March–April composite.
[b] January–February composite.
NA, no analysis.

amounts of thallium-204 standard to solutions containing the normal range of solids.

Table 1 shows a summary of the monthly average gross beta radioactivity in Minnesota municipal water supplies from January–June 1970. Table 2 shows the gross alpha radioactivity in the same samples for the same period of time. Alpha concentrations reported as <1 pCi/liter were considered as 0 pCi/liter for averaging purposes.

The data obtained on gross beta radioactivity in Minnesota surface waters show a variation of concentrations, with no readily apparent trends. Variations in precipitation and flow rates of streams could contribute to this fluctuation. Monthly averages of gross beta radioactivity in Minnesota raw surface waters ranged from <2 to 32 pCi/liter, which is well below the Public Health Service Drinking Water Standards (*1*).

REFERENCE

(*1*) PUBLIC HEALTH SERVICE. Drinking water standards, revised 1962. Public Health Service Publication No. 956, Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (March 1963).

Recent coverage in *Radiological Health Data and Reports*:

Period	Issue
January–June 1969	January 1970
July–December 1969	May 1971

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Tritium Surveillance System, April-June 1971

Office of Radiation Programs
Environmental Protection Agency

The Tritium Surveillance System is an expansion of previous tritium surveillance activities conducted by the Office of Radiation Programs, Environmental Protection Agency (EPA). The principal effort in the past by the Office of Radiation Programs related to tritium releases has been the Tritium in Surface Water Network. This network was established in 1964, to measure and monitor tritium concentrations in major river systems in the United States and to provide surveillance at surface water stations downstream from selected nuclear facilities. The network consisted of selected stations from existing water pollution sampling stations operated by the Office of Water Programs of EPA. The final data from this network for January–June 1970, have been published previously (*1*).

Another effort of the Office of Radiation Programs was a tritium in precipitation program. This project was established in 1967 at selected Radiation Alert Network (RAN) stations covering the United States, including Alaska and Hawaii. The RAN is operated by the National Environmental Research Laboratory of EPA. The data from this project for July–December 1969, have been published previously (*2*). Due to the increased interest in tritium releases from nuclear facilities and the potential long-term accumulation in the environment, a national system was established to incorporate these projects or networks into one overall system.

Present network

The Tritium Surveillance System consists of quarterly drinking water samples from 70 RAN stations, precipitation samples collected daily and analyzed monthly from 8 of the RAN stations and quarterly samples at 39 surface water

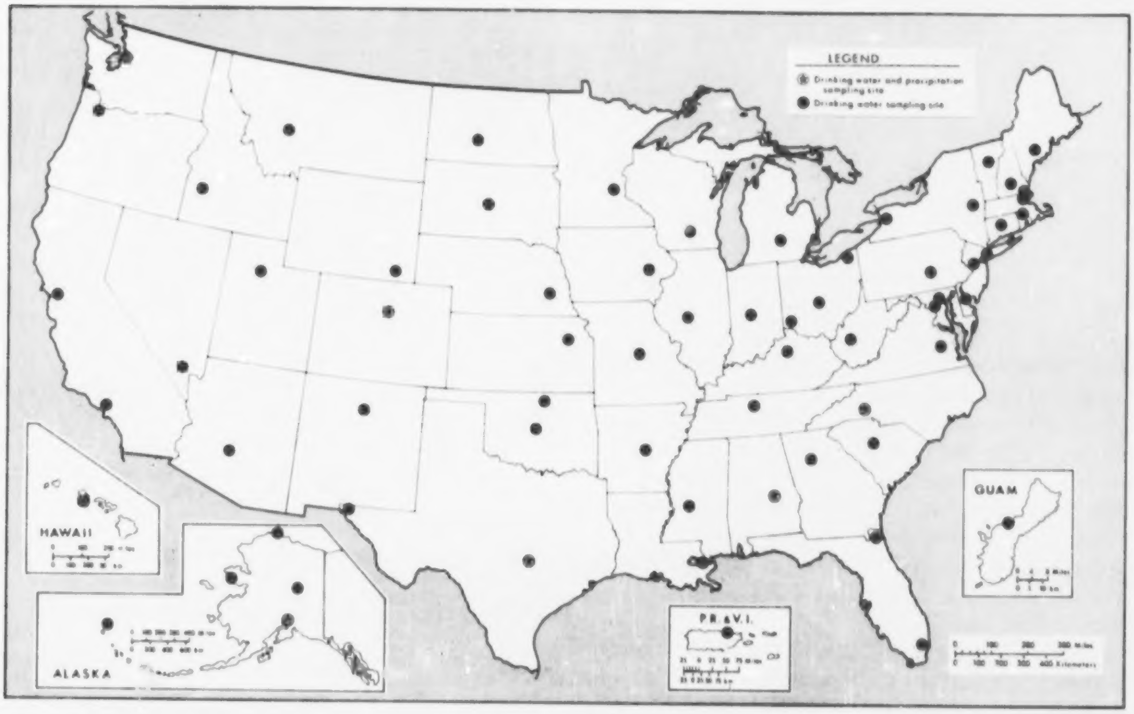
LEGEND
Drinking water and precipitation sampling site
Drinking water sampling site
HAWAII
ALASKA
P.R. & V.I.
GUAM

Figure 1. Drinking water and precipitation sampling locations for tritium surveillance system

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Table 1. Tritium concentration in tap water (RAN stations) April–June 1971

Location		Date collected	Tritium concentration (nCi/liter ± 2σ)
Ala:	Montgomery	4/2	[a]0
Alaska:	Anchorage	NS	
	Attu Island	4/2	0
	Fairbanks	NS	
	Juneau	4/12	0
	Kodiak	4/1	.5 ± .4
	Nome	4/2	0
	Point Barrow	NS	
Ariz:	Phoenix	4/1	0
Ark:	Little Rock	4/1	[a]0
Calif:	Berkeley	4/1	0
	Los Angeles	4/8	0
C.Z:	Ancon	4/19	[a]0
Colo:	Denver	4/12	.9 ± .4
Conn:	Hartford	4/14	0
Del:	Dover	4/14	0
D.C:	Washington	5/7	.3 ± .2
Fla:	Jacksonville	4/1	[a]0
	Miami	4/5	[a]0
Ga:	Atlanta	4/1	[a]0
Guam:	Agana	4/1	0
Hawaii:	Honolulu	4/6	0
Idaho:	Boise	4/1	.7 ± .4
Ill:	Springfield	4/14	0
Ind:	Indianapolis	4/29	0
Iowa:	Iowa City	4/12	.5 ± .4
Kans:	Topeka	4/12	1.0 ± .4
Ky:	Frankfort	4/1	.4 ± .2
La:	New Orleans	4/1	.3 ± .2
Maine:	Augusta	4/13	0
Md:	Baltimore	4/5	.3 ± .2
Mass:	Lawrence	4/12	0
	Winchester	4/7	0
Mich:	Lansing	4/22	0
Minn:	Minneapolis	4/7	.7 ± .4
Miss:	Jackson	4/1	[a]0
Mo:	Jefferson City	4/5	0
Mont:	Helena	4/6	.9 ± .4
Nebr:	Lincoln	4/5	0
Nev:	Las Vegas	4/1	0
N.H:	Concord	4/12	0
N.J:	Trenton	4/12	0
N.Mex:	Sante Fe	4/1	0
N.Y:	Albany	4/13	0
	Buffalo	4/22	0
	New York City	6/7	0
N.C:	Gastonia	4/23	.3 ± .2
N. Dak:	Bismarck	4/20	1.5 ± .4
Ohio:	Cincinnati	4/15	0
	Columbus	4/14	0
	Painesville	4/16	0
Okla:	Oklahoma City	4/2	.4 ± .2
	Ponca City	4/2	.3 ± .2
Oreg:	Portland	4/13	0
Pa:	Harrisburg	4/13	0
P.R:	San Juan	4/26	[a]0
R.I:	Providence	4/20	0
S.C:	Columbia	4/1	[a]0
S. Dak:	Pierre	4/1	1.6 ± .4
Tenn:	Nashville	4/1	[a]0
Tex:	Austin	4/2	.3 ± .2
	El Paso	4/9	.4 ± .2
Utah:	Salt Lake City	4/6	.5 ± .4
Vt:	Barre	4/12	0
Va:	Richmond	4/8	.3 ± .1
Wash:	Seattle	6/16	0
	Spokane	4/5	0
W. Va:	Charleston	4/1	.3 ± .2
Wisc:	Madison	4/15	0
Wyo:	Cheyenne	4/2	1.2 ± .4
Average[b]			0.2

[a] The minimum detection limit for this sample was 0.2 nCi/liter. All values equal to or less than 0.2 nCi/liter have been reported as zero. For all other zero numbers, the minimum detection limit was 0.4 nCi/liter and all values equal to or less than 0.4 nCi/liter have been reported as zero.

[b] This is the average of all concentration values as shown in the table. It should be noted that due to varying sensitivities of procedures between the three laboratories, two different minimum detectable concentrations are used.

NS, no sample.

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Table 2. Tritium concentration in surface water, March–June 1971

Location	Water source	Facility	Collection date	Concentration (nCi/liter ± 2σ)
Ala: Decatur	Tennessee River	Browns Ferry	4/31	0.5 ± .2
Ark: Morrilton	Arkansas River	Arkansas Nuclear	4/15	.3 ± .2
Calif: Eureka	Humboldt Bay	Humboldt Bay	4/16	0
San Onofre	Pacific Ocean	San Onofre	5/25	0
Colo: Greeley	South Platte River	Fort St. Vrain	4/12	1.3 ± .4
Conn: East Haddam	Connecticut River	Connecticut Yankee & Vermont Yankee	4/23	1.7 ± .4
Waterford	Long Island Sound	Millstone	4/9	0
Fla: Crystal River	Gulf of Mexico	Crystal River	5/10	[a]0
Homestead	Biscayne Bay	Turkey Point	5/17	[a]0
Idaho: Buhl	Snake River	National Reactor Testing Station	4/3	.6 ± .4
Ill: Moline	Mississippi River	Quad-Cities	5/3	0
Morris	Illinois River	Dresden and Argonne	4/16	0
La: New Orleans	Mississippi River	(Several)	4/15	.5 ± .2
Md: Conowingo	Susquehanna River	Peach Bottom and Three Mile Island	4/22	0
Lusby	Chesapeake Bay	Calvert Cliffs	6/28	0
Mass: Rowe	Deerfield River	Yankee	5/5	.5 ± .4
Mich: Charlevoix	Lake Michigan	Big Rock Point	5/1	0
Monroe	Lake Erie	Enrico Fermi	5/3	0
South Haven	Lake Michigan	Palisades	4/26	0
Minn: Monticello	Mississippi River	Monticello	4/6	.7 ± .4
Nebr: Rulo	Missouri River	Fort Calhoun and Cooper	4/7	.7 ± .4
Nev: Boulder City	Colorado River	Background	4/1	1.0 ± .4
N.J: Bayside	Delaware River	Salem	4/5	0
N.Y: Ossining	Hudson River	Indian Point	4/19	0
Oswego	Lake Ontario	Nine Mile Point and R. E. Ginna	4/14	0
Poughkeepsie	Hudson River	Background	4/21	0
N.C: Charlotte	Catawba River	Wm B. McGuire	4/21	.4 ± .2
Oreg: Westport	Columbia River	Rainier and Hanford	4/2	1.0 ± .4
S.C: Allendale	Savannah River	Savannah River Plant and Oconee	4/6	4.0 ± .2
Hartsville	Lake Robinson	H. B. Robinson	4/1	.7 ± .2
Tenn: Kingston	Clinch River	Oak Ridge	4/5	7.0 ± .3
Tex: El Paso	Rio Grande River	Los Alamos	4/5	0
Vt: Vernon	Connecticut River	Vermont Yankee	4/9	0
Va: Newport News	James River	Surry	NS	
Wash: Northport	Columbia River	Background	5/5	.9 ± .4
Pasco	Columbia River	Hanford	4/6	.9 ± .4
W Va: Wheeling	Ohio River	Shippingport	4/14	0
Wisc: Two Creeks	Lake Michigan	Point Beach and Kewaunee	4/26	0
Victory	Mississippi River	LaCrosse and Prairie Island	4/16	0
Average[b]				0.6

[a] The minimum detection limit for this sample was 0.2 nCi/liter. All values equal to or less than 0.2 nCi/liter have been reported as zero. For all other numbers, the minimum detection limit was 0.4 nCi/liter and all values equal to or less than 0.4 nCi/liter have been reported as zero.

[b] This is the average of all concentration values as shown in the table. It should be noted that due to varying sensitivities of procedures between the three laboratories, two different minimum detectable concentrations are used.

NS, no sample.

stations (figure 1). The specific locations for the surface water sampling system were determined by examining the water drainage areas to assure that a representative sample from a large area or region was obtained, and if possible, incorporating several nuclear facility sites. All nuclear facilities that were operating, being constructed, or planned through 1975 were considered. Consideration was also given to the current surveillance programs of the States that will be involved in the collection of the samples. The surface water samples are collected quarterly either downstream from a nuclear facility or at a background station.

The tap water samples are collected by the RAN operators on a quarterly basis. The precipitation samples are also collected by the RAN operators on a daily basis.

All samples are sent to one of our laboratories for analysis. Due to the different sensitivity of procedures used by the three laboratories, the minimum detectable concentration varies. Analytical values which are not statistically significant at the 2-sigma confidence level have been reported as zero.

Results and discussion

Table 1 presents the tritium concentrations in drinking water at the RAN stations for April–June 1971. The average tritium concentration was 0.2 nCi/liter.

The radiation dose resulting from the observed tritium concentrations in the drinking water may be evaluated by using the relationship derived by Moghissi and Porter (*3*) from recommendations of the International Commission of Radiological Units and Measurements (*4*). Assuming that the concentration of tritium in all water taken into the body is equal to that found in the drinking water and also that the specific activity of tritium in the body is essentially the same as that in the drinking water, then the radiation dose may be estimated.

The highest individual concentration of tritium observed in the drinking water was 1.7 nCi/liter during the second quarter. This corresponds to a dose of 0.3 mrem/a, or less than 0.2 percent of the Federal Radiation Council's Radiation Protection Guide (170 mrem/a) for an average dose to a suitable sample of the exposed population.

The tritium concentrations for the surface water samples are given in table 2. The highest tritium concentration was 7.0 nCi/liter for the second quarter. Assuming that the specific activity of tritium in the body is essentially the same as that in surface water, this concentration corresponds to a dose of 1.2 mrem/a, or 0.7 percent of the Radiation Protection Guide.

The monthly analyses for tritium in precipitation samples at the 8 RAN stations are shown in table 3.

Other coverage in *Radiological Health Data and Reports*:

Period	Issue
July–December 1970	May 1971
January–March 1971	July 1971

Table 3. Tritium concentrations in precipitation from RAN stations, April–June 1971

Location		Tritium concentration[a] (nCi/liter ±2σ)		
		April	May	June
Ala:	Montgomery	0	0.7 ±0.2	0.3 ±0.2
Alaska:	Anchorage	NS	.4 ± .2	NS
Colo:	Denver	1.3 ±0.2	1.6 ± .2	1.6 ± .2
Hawaii:	Honolulu	0	NS	0
La:	New Orleans	.4 ± .2	0	0
N.C:	Gastonia	.4 ± .2	.3 ± .2	.6 ± .2
Tex:	Austin	NS	NS	NS
Wash:	Seattle	.3 ± .2	.4 ± .2	.7 ± .2

[a] The minimum detection limit for these samples was 0.2 nCi/liter. All values equal to or less than 0.2 nCi/liter have been reported as zero.

NS, no sample.

REFERENCES

(1) BUREAU OF RADIOLOGICAL HEALTH. Tritium in surface water network, January–June 1970. Radiol Health Data Rep 11:638–639 (November 1970).

(2) BUREAU OF RADIOLOGICAL HEALTH. Tritium in precipitation (RAN), July–December 1969. Radiol Health Data Rep 11:354–355 (July 1970).

(3) MOGHISSI, A. A. and C. R. PORTER. Tritium in surface waters in the United States, 1966. Radiol Health Data Rep 9:337–339 (July 1968).

(4) INTERNATIONAL COMMISSION OF RADIOLOGICAL UNITS AND MEASUREMENTS. Recommendations of the International Commission of Radiological Units and Measurements, National Bureau of Standards Handbook 85 (1964).

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SECTION III. AIR AND DEPOSITION

Radioactivity in Airborne Particulates and Precipitation

Continuous surveillance of radioactivity in air and precipitation provides one of the earliest indications of changes in environmental fission product radioactivity. To date, this surveillance has been confined chiefly to gross beta radioanalysis. Although such data are insufficient to assess total human radiation exposure from fallout, they can be used to determine when to modify monitoring in other phases of the environment.

Surveillance data from a number of programs are published monthly and summarized periodically to show current and long-range trends of atmospheric radioactivity in the Western Hemisphere. These include data from activities of the Environmental Protection Agency, the Canadian Department of National Health and Welfare, the Mexican Commission of Nuclear Energy, and the Pan American Health Organization.

In addition to those programs presented in this issue, the following programs were previously covered in *Radiological Health Data and Reports:*

Network	Period	Issue
Fallout in the United States and other areas	July–December 1968 and January–December 1969	January 1971
Plutonium in Airborne Particulates	July–December 1970	June 1971
Surface Air Sampling Program 80th Meridian Network, *HASL*	January–December 1968	April 1971
Mexican Air Monitoring Program	August–December 1970 and January 1971	October 1971

1. Radiation Alert Network
July 1971

National Environmental Research Laboratory
Environmental Protection Agency

Surveillance of atmospheric radioactivity in the United States is conducted by the Radiation Alert Network (RAN) which regularly gathers samples at 70 locations distributed throughout the country (figure 1). Most of these stations are operated by State Health Department personnel.

The station operators perform "field estimates" on the airborne particulate samples at 5 hours after collection, when most of the radon daughter products have decayed. They also perform field estimates on dried precipitation samples and report all results to appropriate Environmental Protection Agency officials by mail or telephone depending on levels found. A complication of the daily field estimates is available upon request from the Data Aquisition and Analysis Branch, Division of Air Quality and Emission Data, EPA, Durham, N.C. A detailed description of the sampling and analytical procedures was presented in the March 1968 issue of *Radiological Health Data and Reports.*

Table 1 presents the monthly average gross beta radioactivity in surface air particulates and deposition by precipitation, as measured by the field estimate technique, during July 1971. All field estimates reported were within normal limits for the reporting station.

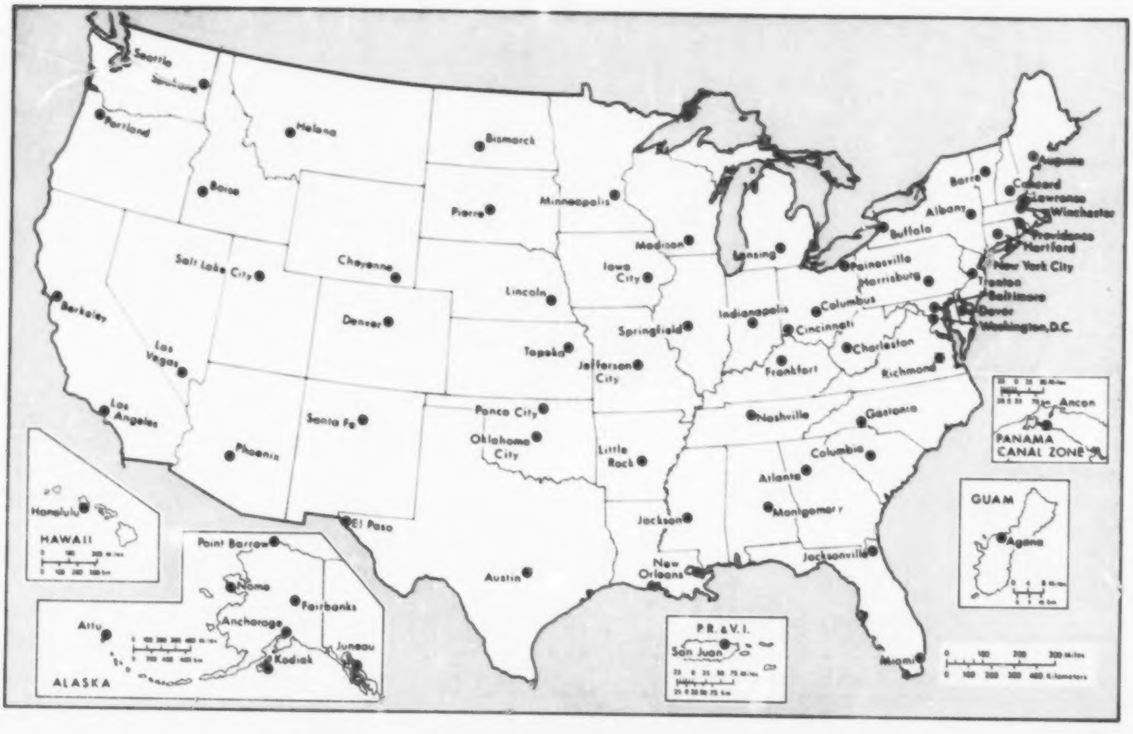
Seattle
Spokane
Portland
Helena
Bismarck
Boise
Pierre
Minneapolis
Madison
Lansing
Buffalo
Albany
Barre
Augusta
Concord
Lawrence
Winchester
Providence
Hartford
New York City
Trenton
Baltimore
Dover
Washington, D.C.
Salt Lake City
Cheyenne
Lincoln
Iowa City
Painesville
Harrisburg
Berkeley
Denver
Indianapolis
Columbus
Cincinnati
Springfield
Charleston
Richmond
Las Vegas
Topeka
Jefferson City
Frankfort
Los Angeles
Ponca City
Santa Fe
Oklahoma City
Nashville
Gastonia
Phoenix
Little Rock
Columbia
Atlanta
Montgomery
Jackson
El Paso
Austin
New Orleans
Jacksonville
Miami
Honolulu
HAWAII
Point Barrow
Nome
Fairbanks
Anchorage
Attu
Juneau
Kodiak
ALASKA
P.R. & V.I.
San Juan
PANAMA CANAL ZONE
Ancon
GUAM
Agana

Figure 1. Radiation Alert Network sampling stations

Table 1. Gross beta radioactivity in surface air and precipitation, July 1971

Station location		Number of samples	Gross beta radioactivity (5-hour field estimate) (pCi/m³)			Precipitation				
						Number of samples	Total depth (mm)	Field estimation of deposition		
			Maximum	Minimum	Average[a]			Number of samples	Depth (mm)	Total deposition (nCi/m²)
Ala:	Montgomery	21	4	0	1	10	504	10	504	148
Alaska:	Anchorage	0				0				
	Attu Island	30	0	0	0	0				
	Fairbanks	17	2	0	1	7	32	7	32	14
	Juneau	10	2	0	1	0				
	Kodiak	1	0	0	0	0				
	Nome	0				0				
	Point Barrow	0				0				
Ariz:	Phoenix	12	4	1	2	0				
Ark:	Little Rock	12	1	0	0	0				
Calif:	Berkeley	21	1	0	0	0				
	Los Angeles	20	2	0	1	0				
C.Z:	Ancon	16	0	0	0	0				
Colo:	Denver	21	5	1	2	3	26	(b)		
Conn:	Hartford	21	2	0	1	6	72	6	72	1
Del:	Dover	20	2	0	1	0				
D.C:	Washington	27	2	0	1	0				
Fla:	Jacksonville	22	1	0	0	10	529	10	529	45
	Miami	20	0	0	0	4	82	4	82	0
Ga:	Atlanta	11	2	1	1	0				
Guam:	Agana	0				0				
Hawaii:	Honolulu	24	1	0	0	1	5	(b)		
Idaho:	Boise	21	3	0	2	0				
Ill:	Springfield	0				0				
Ind:	Indianapolis	19	2	0	1	0				
Iowa:	Iowa City	20	4	1	1	7	150	7	150	0
Kans:	Topeka	21	5	1	2	8	116	8	116	0
Ky:	Frankfort	1	1	1	1	0				
La:	New Orleans	17	1	0	0	12	244	(b)		
Maine:	Augusta	17	2	0	1	6	107	6	107	0
Md:	Baltimore	21	3	0	1	5	44	5	44	0
Mass:	Lawrence	21	2	0	1	6	79	5	59	1
	Winchester	21	2	1	1	5	61	5	61	0
Mich:	Lansing	19	2	1	1	7	93	7	93	8
Minn:	Minneapolis	21	2	0	1	8	128	8	128	37
Miss:	Jackson	19	2	0	1	5	126	5	126	6
Mo:	Jefferson City	22	5	1	2	8	90	8	90	0
Mont:	Helena	19	3	0	1	2	11	2	11	0
Nebr:	Lincoln	21	13	1	4	3	47	3	47	3
Nev:	Las Vegas	21	3	1	1	0				
N.H:	Concord	0				0				
N.J:	Trenton	21	2	0	1	6	83	6	83	9
N. Mex:	Santa Fe	19	2	0	1	7	71	5	40	4
N.Y:	Albany	20	3	0	1	0				
	Buffalo	20	2	0	1	0				
	New York City	0				0				
N.C:	Gastonia	16	3	0	2	7	73	(b)		
N. Dak:	Bismarck	21	4	1	2	2	24	2	24	1
Ohio:	Cincinnati	0				0				
	Columbus	3	2	1	1	0				
	Painesville	20	5	1	2	7	60	7	60	62
Okla:	Oklahoma City	0				0				
	Ponca City	21	5	1	1	8	102	8	102	0
Oreg:	Portland	20	1	0	1	1	3	1	3	0
Pa:	Harrisburg	16	2	0	1	0				
P.R:	San Juan	0				0				
R.I:	Providence	20	2	0	1	4	67	4	67	2
S.C:	Columbia	17	2	0	1	10	277	10	277	0
S. Dak:	Pierre	15	6	1	3	0				
Tenn:	Nashville	21	3	0	1	11	114	11	114	8
Tex:	Austin	0				0				
	El Paso	18	3	0	1	0				
Utah:	Salt Lake City	31	5	1	2	1	20	1	20	6
Vt:	Barre	22	4	0	2	9	109	9	109	12
Va:	Richmond	20	2	0	1	1	21	1	21	18
Wash:	Seattle	9	0	0	0	2	13	(b)		
	Spokane	15	2	0	1	0				
W. Va:	Charleston	19	2		1	8	126	8	126	16
Wisc:	Madison	20	2		1	6	63	6	63	5
Wyo:	Cheyenne	22	7	0	3	1	8	1	8	13
Network summary		1,093	13	0	1	214	118	6	105	13

[a] The monthly average is calculated by weighting the field estimates of individual air samples with length of sampling period.
[b] This station is part of the tritium surveillance system. No gross beta measurements are done.

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2. Canadian Air and Precipitation Monitoring Program,[1] July 1971

Radiation Protection Division
Department of National Health and Welfare

The Radiation Protection Division of the Canadian Department of National Health and Welfare monitors surface air and precipitation in connection with its Radioactive Fallout Study Program. Twenty-four collection stations are located at airports (figure 3), where the sampling equipment is operated by personnel from the Meteorological Services Branch of the Department of Transport. Detailed discussions of the sampling procedures, methods of analysis, and interpretation of results of the radioactive fallout program are contained in reports of the Department of National Health and Welfare (*1–5*).

A summary of the sampling procedures and methods of analysis was presented in the May 1969 issue of *Radiological Health Data and Reports.*

Surface air and precipitation data for July 1971 are presented in table 2.

Table 2. Canadian gross beta radioactivity in surface air and precipitation, July 1971

Station	Number of samples	Air surveillance gross beta radioactivity (pCi/m³)			Precipitation measurements	
		Maximum	Minimum	Average	Average concentration (pCi/liter)	Total deposition (nCi/m²)
Calgary	4	0.5	0.3	0.4	87	6.4
Coral Harbour	3	.2	.1	.1	188	3.7
Edmonton	4	.4	.3	.3	47	8.6
Ft. Churchill	4	.3	.1	.2	199	11.2
Fredericton	4	.4	.2	.3	116	8.9
Goose Bay	4	.4	.1	.2	40	4.9
Halifax	4	.3	.2	.3	58	6.1
Inuvik	4	.2	.1	.1	412	10.2
Montreal	4	.4	.2	.3	191	10.8
Moosonee	4	.4	.1	.3	75	7.1
Ottawa	4	.5	.2	.3	135	15.1
Quebec	4	.4	.3	.4	167	19.6
Regina	4	.5	.3	.4	279	12.2
Resolute	4	.2	.1	.1	NS	NS
St. John's, Nfld	4	.3	.1	.2	72	10.6
Saskatoon	4	.4	.2	.3	155	22.0
Sault Ste. Marie	4	.3	.2	.3	174	13.5
Thunder Bay	4	.3	.2	.3	127	11.9
Toronto	4	.5	.3	.4	167	9.9
Vancouver	4	.3	.1	.2	124	4.2
Whitehorse	4	.5	.3	.4	139	4.5
Windsor	4	.5	.4	.4	36	1.7
Winnipeg	4	.4	.2	.3	192	22.1
Yellowknife	4	.2	.1	.1	410	4.6
Network summary	95	0.5	0.1	0.3	156	10.0

NS, no sample.

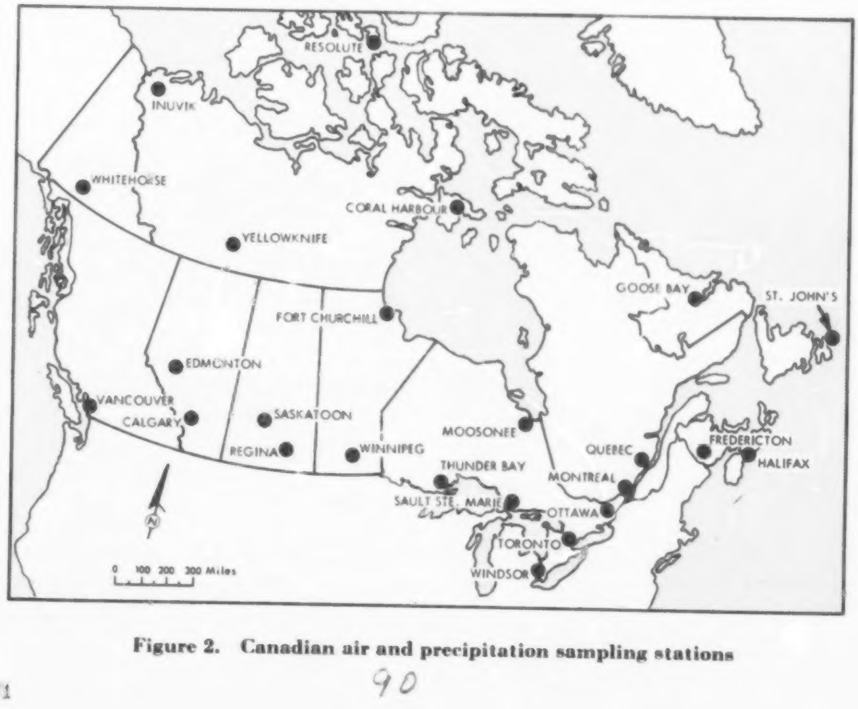
RESOLUTE
INUVIK
WHITEHORSE
CORAL HARBOUR
YELLOWKNIFE
GOOSE BAY
ST. JOHN'S
FORT CHURCHILL
EDMONTON
VANCOUVER
CALGARY
SASKATOON
MOOSONEE
REGINA
WINNIPEG
QUEBEC
FREDERICTON
HALIFAX
THUNDER BAY
MONTREAL
SAULT STE. MARIE
OTTAWA
TORONTO
WINDSOR
N
0 100 200 300 Miles

Figure 2. Canadian air and precipitation sampling stations

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[1] Prepared from information and data obtained from the Canadian Department of National Health and Welfare, Ottawa, Canada.

3. Pan American Air Sampling Program July 1971

Pan American Health Organization and *Environmental Protection Agency*

Gross beta radioactivity in air is monitored by countries in the Americas under the auspices of the collaborative program developed by the Pan American Health Organization (PAHO) and the Environmental Protection Agency (EPA) to assist PAHO-member countries in developing radiological health programs.

The air sampling station locations are shown in figure 3. Analytical techniques were described in the March 1968 issue of *Radiological Health Data and Reports*. The July 1971 air monitoring results from the participating countries are given in table 3.

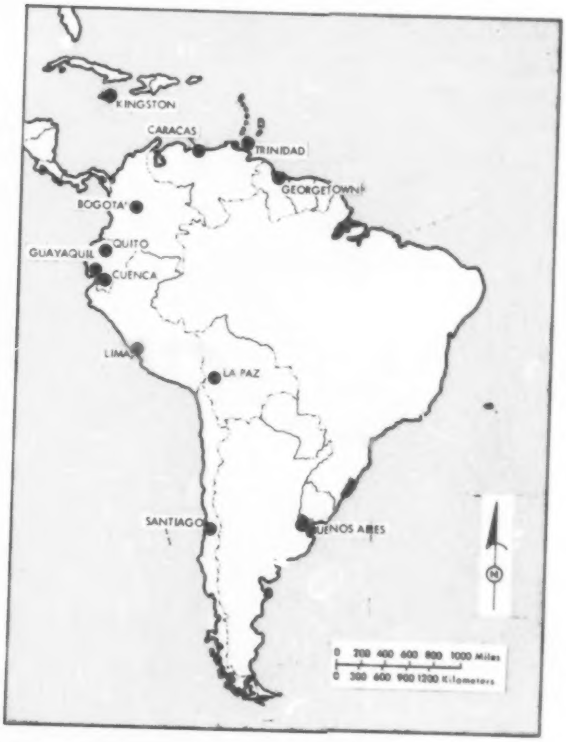

Figure 3. Pan American Air Sampling Program stations

Table 3. Summary of gross beta radioactivity in Pan American surface air, July 1971

Station		Number of samples	Gross beta radioactivity (pCi/m³)		
			Maximum	Minimum	Average
Argentina:	Buenos Aires	0			
Bolivia:	La Paz	18	5.69	0.41	2.25
Chile:	Santiago	30	3.11	.04	1.26
Colombia:	Bogota	0			
Ecuador:	Cuenca	0			
	Guayaquil	21	5.31	.09	1.90
	Quito	19	.55	.02	.20
Guyana:	Georgetown	0			
Jamaica:	Kingston	0			
Peru:	Lima	22	4.48	.39	1.94
Venezuela:	Caracas	18	.31	.02	.21
West Indies:	Trinidad	19	.57	.16	.30
Pan American summary		147	5.69	0.02	1.18

[a] The monthly average is calculated by weighting the individual samples with length of sampling period. Values less than 0.005 pCi/m³ are reported and used in averaging as 0.00 pCi/m³.

4. Plutonium in Airborne Particulates January–March 1971

Office of Radiation Programs
Environmental Protection Agency

The Radiation Alert Network (RAN) of the Environmental Protection Agency routinely collects airborne particulate samples from eleven selected RAN stations for plutonium analyses. The plutonium analyses were initiated in November 1965 and references to the previous results through December 1969 have been published (*6*).

One-half of each individual air filter from the selected stations is sent to the Northeastern Radiological Health Laboratory, Winchester, Mass. The laboratory analyzes a composite of these samples for each station on a quarterly basis. The results for January–March 1971 are presented in table 4. The minimum detectable activities are 0.020 pCi and 0.015 pCi per sample for plutonium-238 and plutonium-239, respectively. The volume of air sampled varies, generally ranging from 20,000 to 30,000 cubic meters per month.

Table 4. Plutonium in airborne particulates January–March 1971

Location		Plutonium-238 (aCi/m³)	Plutonium-239 (aCi/m³)	^{239}Pu/^{238}Pu
Alaska:	Anchorage	3 ±1	13 ± 1	4.3 ±1.5
Ariz:	Phoenix	10 ±3	68 ±11	6.8 ±2.3
Colo:	Denver	9 ±4	55 ±11	6.1 ±3.0
Hawaii:	Honolulu	3 ±1	32 ± 3	10.7 ±3.7
La:	New Orleans	9 ±6	51 ±17	5.7 ±4.2
Md:	Baltimore	ND	18 ± 1	—
N.Y:	Buffalo	5 ±2	28 ± 6	5.6 ±2.5
N.C:	Gastonia	8 ±2	56 ± 5	7.0 ±1.9
S.Dak:	Pierre	ND	39 ±11	—
Tex:	Austin	NA	35 ± 4	—
Wash:	Seattle	2 ±1	19 ± 1	9.5 ±4.8

ND, nondetectable.
NA, no analysis.

Errata: Some previous tables presenting data for plutonium-238 and plutonium-239 in airborne particulates have been in error. The following are corrections or additions to previous data:

a. Corrections—*Radiological Health Data and Reports*—9:761–763 (December 1968)
S. Dak: Pierre...... November 1967
plutonium-238 0.0024 fCi/m³
Tex: Austin......... October 1967
plutonium-239 .0195 fCi/m³
Ariz: Phoenix....... November 1967
plutonium-238 .0066 fCi/m³
Hawaii: Honolulu... November 1967
plutonium-238 .0025 fCi/m³

b. Additions—*Radiological Health Data and Reports*—11:311–312 (June 1970)
Colo: Denver....... August–September 1968
plutonium-238 0.019 fCi/m³
plutonium-239 .035 fCi/m³
^{239}Pu/^{238}Pu 1.8
October–December 1968
plutonium-238 .012 fCi/m³
plutonium-239 .110 fCi/m³
^{239}Pu/^{238}Pu 9.2
Md: Rockville...... October–December 1968
plutonium-238 .006 fCi/m³
plutonium-239 .010 fCi/m³
^{239}Pu/^{238}Pu 1.7
S. Dak: Pierre:...... October–December 1968
plutonium-238 .008 fCi/m³
plutonium-239 .028 fCi/m³
^{239}Pu/^{238}Pu 3.5

REFERENCES

(1) BIRD, P. M., A. H. BOOTH, and P. G. MAR. Annual report of 1959 on the Radioactive Fallout Study Program, CNHW-RP-3. Department of National Health and Welfare, Ottawa, Canada (May 1960).

(2) BIRD, P. M., A. H. BOOTH, and P. G. MAR. Annual report for 1960 on the Radioactive Fallout Study Program, CNHW-RP-4. Department of National Health and Welfare, Ottawa, Canada (December 1961).

(3) MAR, P. G. Annual report for 1961 on the Radioactive Fallout Study Program, CNHW-RP-5. Department of National Health and Welfare, Ottawa, Canada (December 1962).

(4) BEALE, J. and J. GORDON. The operation of the Radiation Protection Division Air Monitoring Program, RPD-11. Department of National Health and Welfare, Ottawa, Canada (July 1962).

(5) BOOTH, A. H. The calculation of permissible levels of fallout in air and water and their use in assessing the significance of 1961 levels in Canada, RPD-21. Department of National Health and Welfare, Ottawa, Canada (August 1962).

(6) BUREAU OF RADIOLOGICAL HEALTH. Plutonium in airborne particulates, April–December 1969. Radiol Health Data Rep 11:552–553 (October 1970).

Other coverage in *Radiological Health Data and Reports:*

Period	Issue
January–June 1970	March 1971
July–December 1970	June 1971

SECTION IV. OTHER DATA

This section presents results from routine sampling of biological materials and other media not reported in the previous sections. Included here are such data as those obtained from human bone sampling, Alaskan surveillance, and environmental monitoring around nuclear facilities.

Environmental Levels of Radioactivity at Atomic Energy Commission Installations

The U.S. Atomic Energy Commission (AEC) receives from its contractors semiannual reports on the environmental levels of radioactivity in the vicinity of major Commission installations. The reports include data from routine monitoring programs where operations are of such a nature that plant environmental surveys are required.

Releases of radioactive materials from AEC installations are governed by radiation standards set forth by AEC's Division of Operational Safety in directives published in the "AEC Manual."[1]

Summaries of the environmental radioactivity data follow for Bettis Atomic Power Laboratory and the Oak Ridge Area.

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[1] Title 10, Code of Federal Regulations, Part 20, "Standards for Protection Against Radiation" contains essentially the standards published in Chapter 0524 of the AEC Manual.

1. Bettis Atomic Power Laboratory[2]
January–December 1970

Westinghouse Electric Corporation
Pittsburgh, Pa.

The Bettis Atomic Power Laboratory (BAPL), operated for the Atomic Energy Commission by the Westinghouse Electric Corporation, was established in 1949 to conduct research and development operations related to naval atomic propulsion systems and to the central station power reactor at Shippingport, Pa. Routine environmental monitoring data are reported for samples taken from the locations shown in figure 1.

Gaseous radioactive waste

The release of gaseous radioactive waste is monitored by continuous air sampling to assure compliance with laboratory regulations. The stack gas limits for the laboratory are based on the 168-hour nonoccupational maximum permissible concentrations in air as specified in AEC Manual Chapter 0524. At no time during 1970 did the concentration of stack releases exceed the required limits. The general public outside the boundary of the laboratory was not exposed to radiation above normal background levels as a result of operations at Bettis.

Total gaseous radioactivity released to the environment during 1970 was 1.64 mCi alpha and less than 164 mCi beta-gamma. Due to a decreased volume of air discharged, the total radioactivity was 13 percent less than last year's quantities; the average concentration of radioactivity, however, remained the same.

Liquid radioactive waste

Radioactive liquids generated in the main laboratory and critical facility areas are collected in retention tanks and sampled for radioanalysis. The laboratory discharge limit of 2,000 pCi/liter is in compliance with AEC Manual Chapter 0524. If activity of liquid wastes is greater than the discharge limit, the water is processed by ion

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[2] Summarized from "Bettis Atomic Power Laboratory, Environmental Monitoring Report, Calendar Year 1970" (WAPD-CL(RA)E-404).

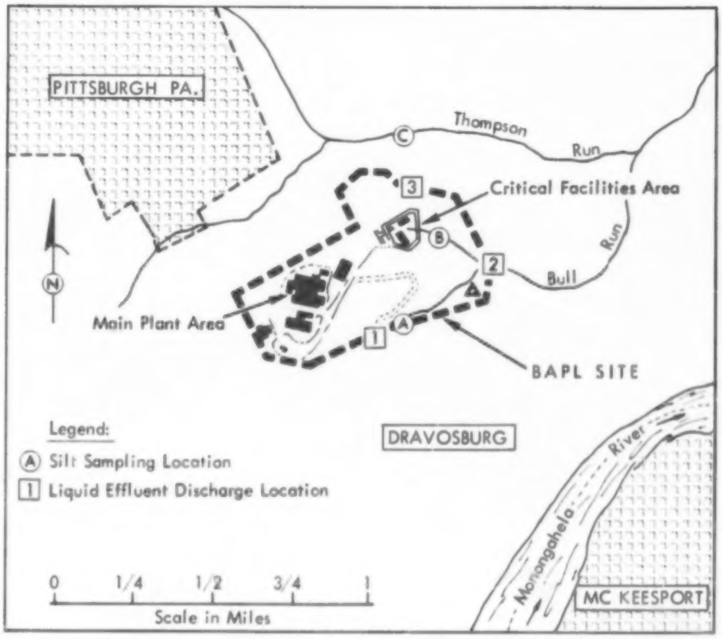
PITTSBURGH PA.
Thompson Run
C
3
Critical Facilities Area
B
2
Bull Run
N
Main Plant Area
1
A
BAPL SITE
Legend:
Ⓐ Silt Sampling Location
1 Liquid Effluent Discharge Location
DRAVOSBURG
Monongahela River
MC KEESPORT
0 1/4 1/2 3/4 1
Scale in Miles

Figure 1. Bettis Atomic Power Laboratory sampling stations

exchange or evaporation. Water less than the discharge limit is released to the storm sewer and diluted with laboratory coolant water, process water, and surface runoff water. This plant effluent is discharged from laboratory property at the three locations shown in figure 1. A composite of the main laboratory effluent released at location 1, is collected and analyzed weekly for gross radioactivity. Critical facility effluent suitable for release is discharged at locations 2 and 3.

The plant effluent water analysis data are summarized in table 1. This shows that the average concentration of the laboratory effluent water is well below the discharge limit of 34 pCi/liter or 1.7 percent of the laboratory discharge limit. The total radioactivity discharged from Bettis Laboratory during 1970 which can be attributed to laboratory operations was 9.9 millicuries.

The average concentrations of gross beta-gamma radioactivity in the main laboratory

Table 1. Average concentration of radioactivity in the Bettis Laboratory liquid effluent, January-December 1970[a]

Period (1970)	Main laboratory			Critical facility		
	Gross radioactivity (pCi/liter)		Volume (10^6 gallons)	Gross radioactivity (pCi/liter)		Volume (10^3 gallons)
	Beta-gamma	Alpha		Beta-gamma	Alpha[b]	
January-March	53	5.1	34.2	560	75	21.0
April-June	31	3.9	52.6	<550	51	68.5
July-September	17	3.2	66.1	<550	<50	4.0
October-December	35	1.6	45.3	800	190	9.5
Summary	31	3.2	198.6	570	68	103.0

[a] Discharge limit 2,000 pCi/liter gross radioactivity. The critical facility effluent is just monitored process water whereas the main laboratory effluent includes the complete storm sewer flow.

[b] Minimum detectable levels for alpha radioactivity for the analytical technique used are 0.1 pCi/liter (main laboratory) and 50 pCi/liter (critical facility). Minimum detectable levels for beta-gamma radioactivity are 0.2 pCi/liter (main laboratory) and 550 pCi/liter (critical facility).

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liquid effluent during 1970 was 31 pCi/liter. This was slightly higher than the average concentration of 28 pCi/liter observed for the year 1969.

Average radioactivity in liquid waste effluent from the critical facility operations during 1970 were 68 pCi/liter of alpha radioactivity and 570 pCi/liter of beta-gamma radioactivity. Comparable values for 1969 were <330 pCi/liter for alpha radioactivity and 1.2 nCi/liter for beta-gamma radioactivity.

Background monitoring stations

Background beta-gamma radiation levels were continuously monitored and recorded at 34 film badge monitoring stations located along the perimeter fence of the laboratory which lies within the controlled confines of the Bettis Atomic Power Laboratory site. In addition, control badges were placed at locations not affected by laboratory operations. These were used to determine the net background radiation level contributed by the laboratory. The results obtained from the environmental monitoring film badges posted at these locations around the laboratory show that radiation exposure to the general public outside the laboratory was not above that received from natural background radiation levels.

Stream silt

Stream silt samples were collected periodically at the three discharge locations (figure 1). The results of analysis of these samples are presented in table 2. The average alpha and beta-gamma radioactivity concentrations of stream silt samples for 1970 were 7.7 pCi/g and 64.4 pCi/g, respectively. These concentrations are consistent with concentrations detected in previous years.

Semiannual analyses for strontium-89 and strontium-90 were obtained for composites of silt samples. Table 2 presents the results of these analyses for samples collected during 1970.

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
January–December 1968	January 1970
January–December 1969	September 1970

Table 2. Radioactivity in stream silt, Bettis, January-December 1970

Period (1970)	Number of samples	Radioactivity (pCi/g)				Average concentration (pCi/g)	
		Alpha		Beta-gamma		Strontium-89	Strontium-90
		Range	Average	Range	Average		
Bull Run Stream	4	5.1– 9.0	7.2	54–117	100	0.50	0.87
C-Area Stream	2	9.4–10.0	9.7	28– 33	30	.17	.28
Thompson Run Stream	2	4.3– 9.0	6.6	25– 27	26	.05	.25
Streets Run (Control Stream)	2	2.0– 5.1	3.5	22– 23	23	.17	.29

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2. Oak Ridge Area[3]
January–June 1970

Union Carbide Nuclear Company
Oak Ridge, Tenn.

Oak Ridge area is a complex made up primarily of the Y-12 Plant, the Oak Ridge National Laboratory (ORNL), and the Oak Ridge Gaseous Diffusion Plant (ORGDP).

Radioactive waste materials arising from the operation of atomic energy installations in the Oak Ridge area are collected, treated, and disposed of according to their physical states. Solid wastes are buried in a Conasauga shale formation which has a marked ability to fix radioactive materials by an ion exchange mechanism. Liquid wastes which contain long-lived fission products are confined in storage tanks or are concentrated by evaporation and disposed of in deep wells. Low-level liquid wastes are discharged after preliminary treatment to the surface streams. Air that may become contaminated by radioactive materials is exhausted to the atmosphere from several tall stacks after treatment by means of scrubbers and filters.

Air monitoring

Atmospheric contamination by radioactive materials occurring in the general environment of East Tennessee is monitored by two systems of monitoring stations. One system consists of nine stations which encircle the plant areas (figure 2) and provide data for evaluating the impact of all Oak Ridge operations on the immediate environment. A second system consists of eight stations encircling the Oak Ridge area at distances of from 12 to 75 miles (figure 3). This system provides data to aid in evaluating local conditions and to assist in determining the spread or dispersal of contamination should a major incident occur.

Sampling for radioactive particulates is carried out by passing air continuously through a filter paper. Average radioactivity concentrations are presented in tables 3 and 4. Airborne radioactive iodine is monitored in the immediate environment of the plant areas by passing air through a cartridge containing activated charcoal.

During the January–June 1970 surveillance period, 244 samples were collected from perim-

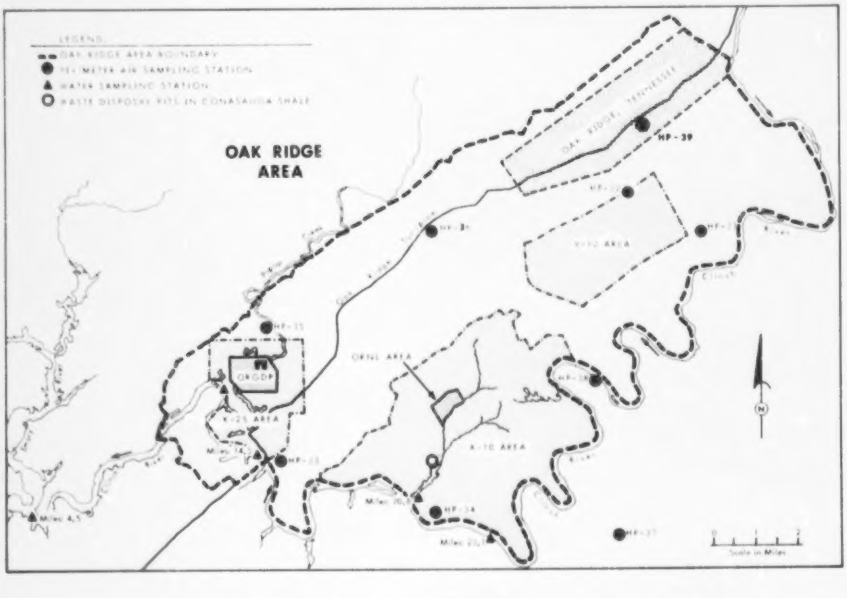
LEGEND
OAK RIDGE AREA BOUNDARY
PERIMETER AIR SAMPLING STATION
WATER SAMPLING STATION
WASTE DISPOSAL PITS IN CONASAUGA SHALE
OAK RIDGE AREA
OAK RIDGE, TENNESSEE
HP-39
Y-12 AREA
ORNL AREA
ORGDP
K-25 AREA
X-10 AREA
HP-35
HP-33
HP-34
HP-37
Miles 14.5
Miles 20.8
Miles 23.1
Miles 4.5
Clinch
River
N
0
1
2
Scale in Miles

Figure 2. Oak Ridge Area environmental sampling locations

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[3] Summarized from "Environmental Levels of Radioactivity for the Oak Ridge area, January–June 1970." Health Physics and Safety Section, Health Physics Division, Oak Ridge National Laboratory.

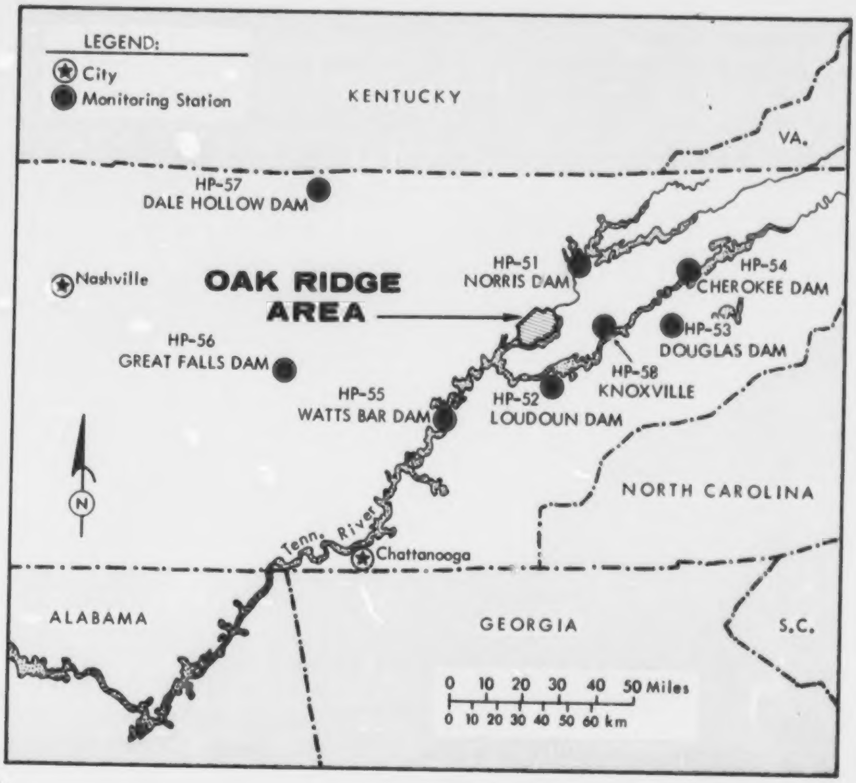
LEGEND:
City
Monitoring Station
KENTUCKY
VA.
HP-57
DALE HOLLOW DAM
Nashville
OAK RIDGE AREA
HP-51
NORRIS DAM
HP-54
CHEROKEE DAM
HP-53
DOUGLAS DAM
HP-58
KNOXVILLE
HP-56
GREAT FALLS DAM
HP-55
WATTS BAR DAM
HP-52
LOUDOUN DAM
N
NORTH CAROLINA
Tenn. River
Chattanooga
ALABAMA
GEORGIA
S.C.
0 10 20 30 40 50 Miles
0 10 20 30 40 50 60 km

Figure 3. Remote air monitoring stations, Oak Ridge area

Table 3. Long-lived gross beta radioactivity of particulates in air, Oak Ridge area, January–June 1970

Perimeter stations						Remote stations					
Station number (figure 3)	Number of samples	Concentration (fCi/m³)			Percent of AEC standard[c]	Station number (figure 2)	Number of samples	Concentration (fCi/m³)			Percent of AEC standard[c]
		Maximum[a]	Minimum[b]	Average				Maximum[a]	Minimum[b]	Average	
HP-31	26	750	33	250	0.25	HP-51	26	630	44	240	0.24
HP-32	26	750	33	280	.28	HP-52	26	810	29	290	.29
HP-33	26	710	21	200	.20	HP-53	26	720	41	260	.26
HP-34	26	590	26	240	.24	HP-54	26	710	25	260	.26
HP-35	26	600	19	250	.25	HP-55	26	970	37	270	.27
HP-36	[d]125	800	15	290	.29	HP-56	25	660	11	260	.26
HP-37	26	600	23	220	.22	HP-57	26	810	40	250	.25
HP-38	26	610	34	250	.25	HP-58	25	730	30	290	.29
HP-39	26	790	8	290	.29						
Summary	333	800	8	250	0.25	Summary	206	970	11	270	0.27

[a] Maximum weekly average concentration.
[b] Minimum weekly average concentration.
[c] The applicable AEC Radiation Protection Standard is 100 pCi/m³.
[d] Sample frequency—5 days per week.

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Table 4. Long-lived gross alpha radioactivity of particulates in air, Oak Ridge area, January–June 1970

Perimeter stations						Remote stations					
Station number (figure 3)	Number of samples	Concentration (fCi/m^3)			Percent of AEC standard[c]	Station number (figure 2)	Number of samples	Concentration (fCi/m^3)			Percent of AEC standard[c]
		Maximum[a]	Minimum[b]	Average				Maximum[a]	Minimum[b]	Average	
HP-31	26	4	<1	1	0.05	HP-51	26	4	<1	1	0.05
HP-32	26	17	<1	4	.20	HP-52	26	5	<1	2	.10
HP-33	26	6	<1	1	.05	HP-53	26	6	<1	1	.05
HP-34	26	5	<1	2	.10	HP-54	26	5	<1	2	.10
HP-35	26	5	<1	1	.05	HP-55	26	5	<1	1	.05
HP-36	[d]125	8	<1	3	.15	HP-56	25	4	<1	1	.05
HP-37	26	4	<1	1	.05	HP-57	26	5	<1	1	.05
HP-38	26	8	<1	2	.10	HP-58	25	6	<1	2	.10
HP-39	26	8	<1	1	.05						
Summary	333	17	<1	2	0.10	Average	206	6	<1	1	0.05

[a] Maximum weekly average concentration.
[b] Minimum weekly average concentration.
[c] The applicable AEC Radiation Protection Standard for natural uranium in air is 2 pCi/m^3.
[d] Sample frequency—5 days per week.

eter monitoring stations and analyzed for iodine-131. Of these, the maximum concentration detected was 0.052 pCi/m^3, the minimum was less than 0.01 pCi/m^3, and the average was 0.01 pCi/m^3. The radiation protection standard specified in the AEC Manual for iodine-131 in the ambient atmosphere in uncontrolled areas is 100 pCi/m^3.

Milk monitoring

Raw milk is monitored for iodine-131 and strontium-90 by the collection and analysis of samples from 12 sampling stations located within a radius of 50 miles of ORNL. Samples are collected weekly at each of eight stations located on the fringe of the Oak Ridge area. Four stations, located more remotely with respect to the Oak Ridge operations, are sampled at a rate of one station each week. The purpose of the milk sampling program is twofold: first, samples collected in the immediate vicinity of the Oak Ridge area provide data by which one may evaluate possible exposure to the neighboring population resulting from waste releases from Oak Ridge operations; second, samples collected at the more remote stations provide background data which are essential in establishing the proper index for the evaluation of data obtained from local samples. The concentrations of iodine-131 and strontium-90 detected in raw milk samples during the period are given in table 5.

Table 5. Radionuclides in raw milk, Oak Ridge area January–June 1970

Radionuclide and location	Concentration (pCi/liter)		
	Maximum	Minimum[a]	Average
Iodine-131:			
Immediate environs	27	<10	<10
Remote environs	<10	<10	<10
Strontium-90:			
Immediate environs	39	2.0	11.2
Remote environs	17	< 2.0	8.9

[a] The minimum detectable concentrations of iodine-131 and strontium-90 in milk are 10 pCi/liter and 2 pCi/liter, respectively. In averaging, one-half of the minimum detectable concentration was used for all samples showing an activity less than this concentration.

Water monitoring

Large volume, low-level wastes originating at ORNL are discharged, after some preliminary treatment, into the Tennessee River system by way of White Oak Creek and the Clinch River. Liquid wastes originating at the ORGDP and Y-12 Plant are discharged to Poplar Creek and thence to the Clinch River. Releases are controlled so that resulting average concentrations in the Clinch River comply with AEC radiation protection standards. The radioactivity concentration from White Oak Creek is measured, and concentration values for the Clinch River are calculated on the basis of the dilution provided by the river.

Water samples are taken at a number of locations in the Clinch River, beginning at a point

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above the entry of wastes into the river and ending at Center's Ferry near Kingston, Tenn. Stream gauging operations are carried on continuously to obtain dilution factors for calculating the probable concentrations of wastes in the river. Samples are analyzed for the long-lived beta-particle emitters, uranium, and the transuranic alpha-particle emitters. The average concentrations of major radionuclides in the Clinch River are given in table 6 for the period from January–June 1970.

Table 6. Concentrations of major radionuclides in the Clinch River, January–June 1970

Radionuclide	Average concentration (pCi/liter)			
	Location on Clinch River[a]			
	Mile 23.1 (Upstream)	Mile 20.8[b] (Outfall)	Mile 14.5	Mile 4.5 (Downstream)
Strontium-90	0.6	0.6	1.8	1.3
Cerium-144	.2	< .1	.4	.3
Cesium-137	.7	.3	2.2	2.9
Ruthenium-103, 106	.3	.2	1.6	.3
Cobalt-60	.6	.2	2.2	1.7
Zirconium-niobium-95	.4	< .1	.4	.4
Tritium	2,250	1,900	5,300	3,100

[a] The location on Clinch River is given in terms of the distance upstream from the Tennessee River (figure 1).

[b] Values given for this location are calculated values based on the concentrations of waste released from White Oak Dam and the dilution afforded by the Clinch River. They do not include radioactive materials (e.g., fallout) that may enter the river upstream from Mile 20.8.

Two quarterly composite water samples from the Clinch River were analyzed for uranium during this period. For these samples, the uranium concentrations were less than 1 pCi/liter, the level of detectability. The AEC radiation protection standard for natural uranium in water released to unrestricted areas is 20 nCi/liter.

Gamma measurements

External gamma radiation levels are measured monthly at a number of locations in the Oak Ridge area. Measurements are taken with a Geiger-Mueller tube at a distance of 3 feet above the ground. The results are shown in table 7.

Discussion of data

The average air contamination levels for gross beta radioactivity, as shown by the continuous air monitoring filter data, for both the immediate and remote environs of the plants (figures 2 and 3) were 0.25 percent and 0.27 percent, respectively, of the AEC radiation protection standard for uncontrolled areas.

The average air contamination levels for gross alpha radioactivity, as shown by the continuous air monitoring filter data, for the immediate and remote environs of the plants were 0.10 percent and 0.05 percent, respectively, of the AEC radiation protection standard for natural uranium for uncontrolled areas.

The average concentration of iodine-131 in air in the immediate environs of the plants was 0.01 pCi/m^3. This is approximately 0.01 percent of the AEC radiation standard for uncontrolled areas.

The average concentrations of iodine-131 in raw milk in the immediate and remote environs of the Oak Ridge area were both less than 10 pCi/liter. These levels fall within the limits of FRC Range I, if the average intake per individual is assumed to be 1 liter of milk per day.

The average concentrations of strontium-90 in raw milk in the immediate and remote environs

Table 7. External gamma radiation levels,[a] Oak Ridge area, January–June 1970

Location	Exposure (mR/h)						
	January	February	March	April	May	June	Average
Kerr Hollow Gate	0.009	0.009	0.023	0.014	0.013	0.011	0.013
Y-12, East Portal	.011	.013	.015	.013	.011	.011	.012
Newcomb Road	.011	.016	.011	.010	.014	.014	.013
Gallaher Gate	.012	.018	.013	.009	.013	.019	.014
White Wing Gate	.015	.010	.024	.011	.013	.012	.014

[a] The background in the Oak Ridge area, determined in 1943, was approximately 0.012 mR/h.

of the controlled areas was 11.2 pCi/liter and 8.9 pCi/liter, respectively. The average falls within the limits of FRC Range I for transient rates of daily intake of strontium-90 for application to the average of suitable samples of an exposed population.

The percent maximum concentration of radioactivity in the Clinch River at all points of measurements was less than 1 percent of the AEC radiation protection standards. The average concentration of transuranic alpha-particle emitters in the Clinch River at Mile 20.8 was 0.08 pCi/liter which is 0.08 percent of the AEC radiation protection standard for water containing a mixture of unknown radionuclides.

The average concentration of natural uranium materials in the Clinch River reflecting the effects of all Oak Ridge plants was less than 0.1 percent of the AEC radiation standard for uranium.

The average external gamma radiation measured in the town of Oak Ridge and at the perimeter of the Oak Ridge areas was 0.013 mR/h, which is approximately the same as that level measured during the period prior to Oak Ridge operations.

Recent coverage in *Radiological Health Data and Reports*:

Period	Issue
January–June 1969	May 1970
July–December 1969	August 1971

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Reported Nuclear Detonations, October 1971

(Includes seismic signals from foreign test areas)

Announcement was made by the U.S. Atomic Energy Commission of only one U.S. nuclear test during October 1971. This nuclear test was conducted underground by the Atomic Energy Commission at its Nevada Test Site on October 8, 1971, and was of low yield (less than 20 kilotons TNT equivalent).

Seismic signals, presumably from a Soviet underground nuclear explosion, were recorded by the United States on October 9, 1971. The signals originated at approximately 2:00 a.m. (EDT) Saturday morning at the Semipalatinsk nuclear test area, and were equivalent to those of an underground nuclear explosion in the yield range of 20–200 kilotons.

On October 21, 1971, the United States recorded seismic signals, presumably from a Soviet underground nuclear explosion. The signals originated at approximately 2:00 a.m., EDT, at the Semipalatinsk nuclear test area and were equivalent to those of an underground nuclear explosion in the yield range of 20–200 kilotons.

Seismic signals, presumably from a Soviet underground nuclear explosion, were recorded by the United States on October 22, 1971. The signals originated at approximately 1:00 a.m., EDT, in the southern Ural area of the U.S.S.R. and were equivalent to those of an underground nuclear explosion in the yield range of 20–200 kilotons.

Not all of the nuclear detonations in the United States are announced immediately, therefore, the information in this section may not be complete. A complete list of announced U. S. nuclear detonations may be obtained upon request from the Division of Public Information, U. S. Atomic Energy Commission, Washington, D. C. 20545.

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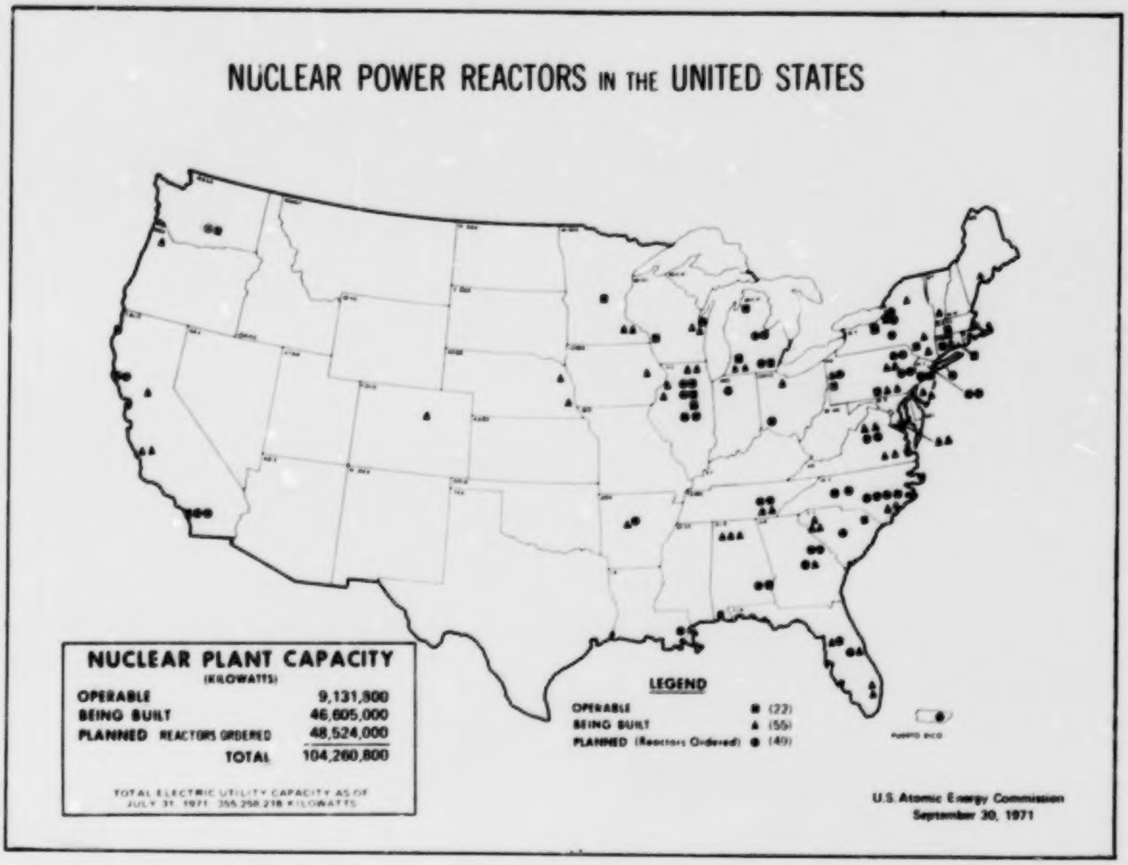
☆ U.S. GOVERNMENT PRINTING OFFICE: 1971-484-481/4



NUCLEAR POWER REACTORS IN THE UNITED STATES
NUCLEAR PLANT CAPACITY
(KILOWATTS)
OPERABLE 9,131,800
BEING BUILT 46,605,000
PLANNED REACTORS ORDERED 48,524,000
TOTAL 104,260,800
TOTAL ELECTRIC UTILITY CAPACITY AS OF JULY 31, 1971: 355,258,218 KILOWATTS
LEGEND
OPERABLE ■ (22)
BEING BUILT ▲ (55)
PLANNED (Reactors Ordered) ● (49)
PUERTO RICO
U.S. Atomic Energy Commission
September 30, 1971

Figure 1. Nuclear power reactors in the United States September 30, 1971

Nuclear Power Reactors in the United States
September 30, 1971

Each quarter year, the Atomic Energy Commission releases information on the status of all present and proposed civilian nuclear power generating units in the United States. This information is reproduced for interested readers of Radiological Health Data and Reports.

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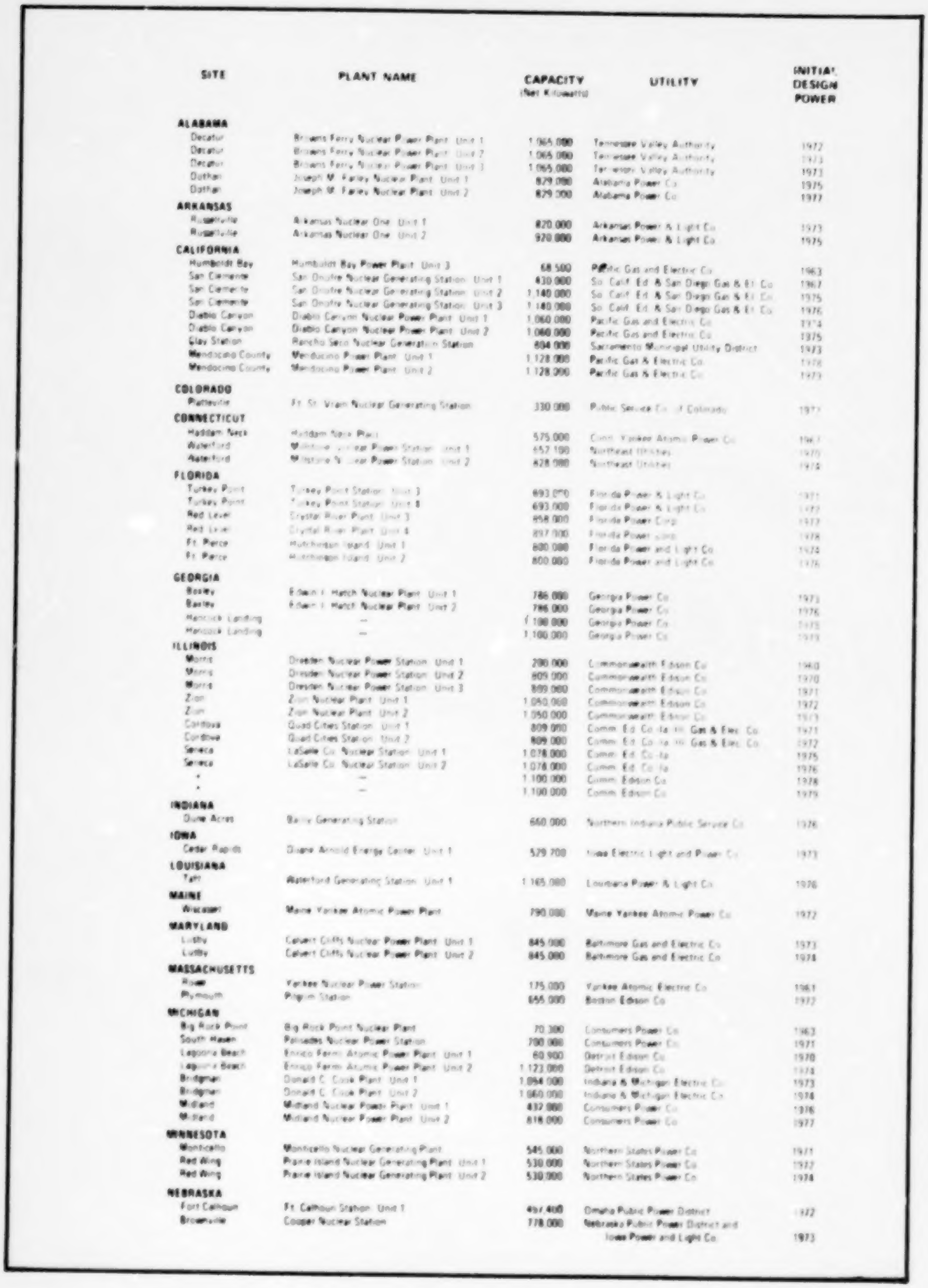

SITE	PLANT NAME	CAPACITY (Net Kilowatts)	UTILITY	INITIAL DESIGN POWER
ALABAMA				
Decatur	Browns Ferry Nuclear Power Plant Unit 1	1,065,000	Tennessee Valley Authority	1972
Decatur	Browns Ferry Nuclear Power Plant Unit 2	1,065,000	Tennessee Valley Authority	1973
Decatur	Browns Ferry Nuclear Power Plant Unit 3	1,065,000	Tennessee Valley Authority	1973
Dothan	Joseph M. Farley Nuclear Plant Unit 1	829,000	Alabama Power Co	1975
Dothan	Joseph M. Farley Nuclear Plant Unit 2	829,000	Alabama Power Co	1977
ARKANSAS				
Russellville	Arkansas Nuclear One Unit 1	820,000	Arkansas Power & Light Co	1973
Russellville	Arkansas Nuclear One Unit 2	920,000	Arkansas Power & Light Co	1975
CALIFORNIA				
Humboldt Bay	Humboldt Bay Power Plant Unit 3	68,500	Pacific Gas and Electric Co	1963
San Clemente	San Onofre Nuclear Generating Station Unit 1	430,000	So. Calif. Ed. & San Diego Gas & El. Co	1967
San Clemente	San Onofre Nuclear Generating Station Unit 2	1,140,000	So. Calif. Ed. & San Diego Gas & El. Co	1975
San Clemente	San Onofre Nuclear Generating Station Unit 3	1,140,000	So. Calif. Ed. & San Diego Gas & El. Co	1976
Diablo Canyon	Diablo Canyon Nuclear Power Plant Unit 1	1,060,000	Pacific Gas and Electric Co	1974
Diablo Canyon	Diablo Canyon Nuclear Power Plant Unit 2	1,060,000	Pacific Gas and Electric Co	1975
Clay Station	Rancho Seco Nuclear Generation Station	804,000	Sacramento Municipal Utility District	1973
Mendocino County	Mendocino Power Plant Unit 1	1,128,000	Pacific Gas & Electric Co	1978
Mendocino County	Mendocino Power Plant Unit 2	1,128,000	Pacific Gas & Electric Co	1979
COLORADO				
Platteville	Ft. St. Vrain Nuclear Generating Station	330,000	Public Service Co. of Colorado	1972
CONNECTICUT				
Haddam Neck	Haddam Neck Plant	575,000	Conn. Yankee Atomic Power Co	1967
Waterford	Millstone Nuclear Power Station Unit 1	652,100	Northeast Utilities	1970
Waterford	Millstone Nuclear Power Station Unit 2	828,000	Northeast Utilities	1974
FLORIDA				
Turkey Point	Turkey Point Station Unit 3	693,000	Florida Power & Light Co	1971
Turkey Point	Turkey Point Station Unit 4	693,000	Florida Power & Light Co	1972
Red Level	Crystal River Plant Unit 3	858,000	Florida Power Corp	1972
Red Level	Crystal River Plant Unit 4	897,000	Florida Power Corp	1978
Ft. Pierce	Hutchinson Island Unit 1	800,000	Florida Power and Light Co	1974
Ft. Pierce	Hutchinson Island Unit 2	800,000	Florida Power and Light Co	1976
GEORGIA				
Baxley	Edwin I. Hatch Nuclear Plant Unit 1	786,000	Georgia Power Co	1973
Baxley	Edwin I. Hatch Nuclear Plant Unit 2	786,000	Georgia Power Co	1976
Hancock Landing	—	1,100,000	Georgia Power Co	1975
Hancock Landing	—	1,100,000	Georgia Power Co	1979
ILLINOIS				
Morris	Dresden Nuclear Power Station Unit 1	200,000	Commonwealth Edison Co	1960
Morris	Dresden Nuclear Power Station Unit 2	809,000	Commonwealth Edison Co	1970
Morris	Dresden Nuclear Power Station Unit 3	809,000	Commonwealth Edison Co	1971
Zion	Zion Nuclear Plant Unit 1	1,050,000	Commonwealth Edison Co	1972
Zion	Zion Nuclear Plant Unit 2	1,050,000	Commonwealth Edison Co	1973
Cordova	Quad Cities Station Unit 1	809,000	Comm. Ed. Co.-Ia.-Ill. Gas & Elec. Co	1971
Cordova	Quad Cities Station Unit 2	809,000	Comm. Ed. Co.-Ia.-Ill. Gas & Elec. Co	1972
Seneca	LaSalle Co. Nuclear Station Unit 1	1,078,000	Comm. Ed. Co.-Ia	1975
Seneca	LaSalle Co. Nuclear Station Unit 2	1,078,000	Comm. Ed. Co.-Ia	1976
*	—	1,100,000	Comm. Edison Co	1978
*	—	1,100,000	Comm. Edison Co	1979
INDIANA				
Dune Acres	Bailly Generating Station	660,000	Northern Indiana Public Service Co	1976
IOWA				
Cedar Rapids	Duane Arnold Energy Center Unit 1	529,700	Iowa Electric Light and Power Co	1973
LOUISIANA				
Taft	Waterford Generating Station Unit 1	1,165,000	Louisiana Power & Light Co	1976
MAINE				
Wiscasset	Maine Yankee Atomic Power Plant	790,000	Maine Yankee Atomic Power Co	1972
MARYLAND				
Lusby	Calvert Cliffs Nuclear Power Plant Unit 1	845,000	Baltimore Gas and Electric Co	1973
Lusby	Calvert Cliffs Nuclear Power Plant Unit 2	845,000	Baltimore Gas and Electric Co	1974
MASSACHUSETTS				
Rowe	Yankee Nuclear Power Station	175,000	Yankee Atomic Electric Co	1961
Plymouth	Pilgrim Station	655,000	Boston Edison Co	1972
MICHIGAN				
Big Rock Point	Big Rock Point Nuclear Plant	70,300	Consumers Power Co	1963
South Haven	Palisades Nuclear Power Station	700,000	Consumers Power Co	1971
Lagoona Beach	Enrico Fermi Atomic Power Plant Unit 1	60,900	Detroit Edison Co	1970
Lagoona Beach	Enrico Fermi Atomic Power Plant Unit 2	1,123,000	Detroit Edison Co	1974
Bridgman	Donald C. Cook Plant Unit 1	1,054,000	Indiana & Michigan Electric Co	1973
Bridgman	Donald C. Cook Plant Unit 2	1,060,000	Indiana & Michigan Electric Co	1974
Midland	Midland Nuclear Power Plant Unit 1	432,000	Consumers Power Co	1976
Midland	Midland Nuclear Power Plant Unit 2	818,000	Consumers Power Co	1977
MINNESOTA				
Monticello	Monticello Nuclear Generating Plant	545,000	Northern States Power Co	1971
Red Wing	Prairie Island Nuclear Generating Plant Unit 1	530,000	Northern States Power Co	1972
Red Wing	Prairie Island Nuclear Generating Plant Unit 2	530,000	Northern States Power Co	1974
NEBRASKA				
Fort Calhoun	Ft. Calhoun Station Unit 1	457,400	Omaha Public Power District	1972
Brownville	Cooper Nuclear Station	778,000	Nebraska Public Power District and Iowa Power and Light Co	1973

Figure 1. Nuclear power reactors in the United States—continued

SITE	PLANT NAME	CAPACITY (Net Kilowatts)	UTILITY	INITIAL DESIG POWE
NEW JERSEY				
Toms River	Oyster Creek Nuclear Power Plant Unit 1	560 000	Jersey Central Power & Light Co	1969
Lacey Township	Forked River Generating Station Unit 1	1 140 000	Jersey Central Power & Light Co	1977
Salem	Salem Nuclear Generating Station Unit 1	1 090 000	Public Service Electric and Gas, N. J.	1973
Salem	Salem Nuclear Generating Station Unit 2	1 115 000	Public Service Electric and Gas, N. J.	1974
Bordentown	Newbold Nuclear Generating Station Unit 1	1 088 000	Public Service Electric and Gas, N. J.	1975
Bordentown	Newbold Nuclear Generating Station Unit 2	1 088 000	Public Service Electric and Gas, N. J.	1977
NEW YORK				
Indian Point	Indian Point Station Unit 1	265 000	Consolidated Edison Co	1963
Indian Point	Indian Point Station Unit 2	873 000	Consolidated Edison Co	1972
Indian Point	Indian Point Station Unit 3	965 000	Consolidated Edison Co	1973
Scriba	Nine Mile Point Nuclear Station Unit 1	625 000	Niagara Mohawk Power Co	1970
Scriba	Nine Mile Point Nuclear Station Unit 2	1 100 000	Niagara Mohawk Power Co	1977
Rochester	R. E. Ginna Nuclear Power Plant Unit 1	420 000	Rochester Gas & Electric Co	1970
Brookhaven	Shoreham Nuclear Power Station	819 000	Long Island Lighting Co	1975
Lansing	Bell Station	838 000	New York State Electric & Gas Co	1978
Verplanck	Con. Ed. Nuclear - E	1 115 000	Consolidated Edison Co	1977
Scriba	James A. Fitzpatrick Nuclear Power Plant	821 000	Power Authority of State of N. Y.	1973
NORTH CAROLINA				
Southport	Brunswick Steam Electric Plant Unit 1	821 000	Carolina Power and Light Co	1975
Southport	Brunswick Steam Electric Plant Unit 2	821 000	Carolina Power and Light Co	1974
Cowans Ford Dam	Wm. B. McGuire Nuclear Station Unit 1	1 150 000	Duke Power Co	1975
Cowans Ford Dam	Wm. B. McGuire Nuclear Station Unit 2	1 150 000	Duke Power Co	1977
Bonsal	Shearon Harris Plant Unit 1	915 000	Carolina Power & Light Co	1977
Bonsal	Shearon Harris Plant Unit 2	915 000	Carolina Power & Light Co	1978
Bonsal	Shearon Harris Plant Unit 3	915 000	Carolina Power & Light Co	1979
Bonsal	Shearon Harris Plant Unit 4	915 000	Carolina Power & Light Co	1980
OHIO				
Oak Harbor	Davis Besse Nuclear Power Station	872 000	Toledo Edison-Cleveland Electric Illuminating Co	1974
Moscow	Wm. H. Zimmer Nuclear Power Station Unit 1	810 000	Cincinnati Gas & Electric Co	1974
OREGON				
Prescott	Trojan Station	1 130 000	Portland General Electric Co	1974
PENNSYLVANIA				
Peach Bottom	Peach Bottom Atomic Power Station Unit 1	40 000	Philadelphia Electric Co	1967
Peach Bottom	Peach Bottom Atomic Power Station Unit 2	1 065 000	Philadelphia Electric Co	1973
Peach Bottom	Peach Bottom Atomic Power Station Unit 3	1 065 000	Philadelphia Electric Co	1974
Pottstown	Limerick Generating Station Unit 1	1 065 000	Philadelphia Electric Co	1975
Pottstown	Limerick Generating Station Unit 2	1 065 000	Philadelphia Electric Co	1977
Shippingport	Shippingport Atomic Power Station Unit 1	90 000	Duquesne Light Co	1957
Shippingport	Beaver Valley Power Station Unit 1	847 000	Duquesne Light Co.-Ohio Edison Co	1973
Shippingport	Beaver Valley Power Station Unit 2	847 000	Duquesne Light Co.-Ohio Edison Co	1978
Middletown	Three Mile Island Nuclear Station Unit 1	831 000	Metropolitan Edison Co	1972
Middletown	Three Mile Island Nuclear Station Unit 2	907 000	Jersey Central Power & Light Co	1974
Berwick	Susquehanna Steam Electric Station Unit 1	1 052 000	Pennsylvania Power and Light	1978
Berwick	Susquehanna Steam Electric Station Unit 2	1 052 000	Pennsylvania Power and Light	1980
SOUTH CAROLINA				
Hartsville	H. B. Robinson S. E. Plant Unit 2	700 000	Carolina Power & Light Co	1971
Seneca	Oconee Nuclear Station Unit 1	841 000	Duke Power Co	1972
Seneca	Oconee Nuclear Station Unit 2	886 000	Duke Power Co	1972
Seneca	Oconee Nuclear Station Unit 3	886 000	Duke Power Co	1973
Parr	Virgil C Summer Nuclear Station Unit 1	900 000	South Carolina Electric & Gas Co	1977
TENNESSEE				
Daisy	Sequoyah Nuclear Power Plant Unit 1	1 124 000	Tennessee Valley Authority	1974
Daisy	Sequoyah Nuclear Power Plant Unit 2	1 124 000	Tennessee Valley Authority	1974
Spring City	Watts Bar Nuclear Plant Unit 1	1 169 000	Tennessee Valley Authority	1976
Spring City	Watts Bar Nuclear Plant Unit 2	1 169 000	Tennessee Valley Authority	1977
VERMONT				
Vernon	Vermont Yankee Generating Station	513 900	Vermont Yankee Nuclear Power Corp	1971
VIRGINIA				
Gravel Neck	Surry Power Station Unit 1	780 000	Virginia Electric & Power Co	1972
Gravel Neck	Surry Power Station Unit 2	780 000	Virginia Electric & Power Co	1972
Mineral	North Anna Power Station Unit 1	845 000	Virginia Electric & Power Co	1974
Mineral	North Anna Power Station Unit 2	845 000	Virginia Electric & Power Co	1975
Mineral	North Anna Power Station Unit 3	900 000	Virginia Electric & Power Co	1977
Mineral	North Anna Power Station Unit 4	900 000	Virginia Electric & Power Co	1978
WASHINGTON				
Richland	N Reactor-WPPSS Steam	790 000	Atomic Energy Commission	1966
Richland	Hanford No. 2	1 103 000	Washington Public Power Supply System	1977
WISCONSIN				
Genoa	Genoa Nuclear Generating Station	50 000	Dairyland Power Cooperative	1969
Two Creeks	Point Beach Nuclear Plant Unit 1	497 000	Wisconsin Michigan Power Co	1971
Two Creeks	Point Beach Nuclear Plant Unit 2	497 000	Wisconsin Michigan Power Co	1971
Carlton	Kewaunee Nuclear Power Plant Unit 1	541 000	Wisconsin Public Service Co	1972
PUERTO RICO				
Puerto De Jobos	Aguirre Nuclear Power Plant	583 000	Puerto Rico Water Resources Authority	1975
*	—	1 175 000	Tennessee Valley Authority	1977
*	—	1 175 000	Tennessee Valley Authority	1978

---

* Site not selected

Figure 1. Nuclear power reactors in the United States—continued

SYNOPSES

Synopses of reports, incorporating a list of key words, are furnished below in reference card format for the convenience of readers who may wish to clip them for their files.

STRONTIUM-90 IN HUMAN VERTEBRAE IN CZECHOSLOVAKIA, 1964–1969.

Z Brezík. Radiological Health Data and Reports, Vol. 12, November 1971, pp. 541–545.

The Institute of Radiation Hygiene has been conducting a continuous determination of strontium-90 in human vertebrae since the beginning of 1964. Specimens were collected at autopsies of inhabitants of Prague and Middle Bohemia, aged 0–60 years. In the period, 1964–1969, about 1,450 specimens were analyzed and the results divided into 12 age groups. The peak strontium-90 level occurred in 1964 in child group 6–11 months. In the following years, the decreasing trend of strontium-90 values is evident especially in child groups. A frequency histogram of values obtained displays a slightly positive skewness in all years of the study. When plotted, the data indicate a log normal distribution.

An editor's note gives a comparison of data during a corresponding period in the United States and some European countries.

KEYWORDS: Czechoslovakia, human vertebrae, strontium-90, strontium-90 to calcium ratios

RESULTS OF A SURVEY OF X RADIATION FROM COLOR TELEVISION RECEIVERS IN THE METROPOLITAN AREA OF SAN JUAN, PUERTO RICO, 1969–1970.

Radiological Health Program, Commonwealth of Puerto Rico Department of Health. Radiological Health Data and Reports, Vol. 12, November 1971, pp. 547–551.

In 1969–1970, the Puerto Rico Department of Health surveyed 1,276 color television sets for emission of radiation. Only 34 (2.7 percent) of these sets were found to be emitting radiation in excess of 0.5 mR/h at 5 cm from the surface of the receiver.

KEYWORDS: Color television, Puerto Rico, survey, x-radiation.

RADIOLOGICAL HEALTH DATA AND REPORTS

Volume 12, Number 12, December 1971

Radiological Health Data and Reports, a monthly publication of the Environmental Protection Agency, presents data and reports provided by Federal, State, and foreign governmental agencies, and other cooperating organizations. Pertinent original data and interpretive manuscripts are invited from investigators.

In August 1959, the President directed the Secretary of Health, Education, and Welfare to intensify Departmental activities in the field of radiological health. The Department was assigned responsibility within the Executive Branch for the collation, analysis, and interpretation of data on environmental radiation levels. This responsibility was delegated to the Bureau of Radiological Health, Public Health Service. Pursuant to the Reorganization Plan No. 3 of 1970, effective December 2, 1970, this responsibility was transferred to the Radiation Office of the Environmental Protection Agency which was established by this reorganization.

The Federal agencies listed below appoint their representatives to a Board of Editorial Advisors. Members of the Board advise on general publications policy; secure appropriate data and manuscripts from their agencies; and review those contents which relate to the special functions of their agencies.

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Atomic Energy Commission

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RADIOLOGICAL HEALTH DATA AND REPORTS

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Office of Radiation Programs

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ENVIRONMENTAL PROTECTION AGENCY
William D. Ruckelshaus, Administrator

Impact of Tritium on the Watch Industry, 1966–1970

F. J. Bradley, R. Blais and A. Jones[1]

Tritium contamination from self-luminous watches at wholesale importers, retailers, and refinishers has been investigated. Air, surface-wipe, and urine samples were analyzed for tritium content by liquid scintillation counting to determine the extent of the contamination.

Eleven storage vaults were surveyed, and the highest human exposure (0.5 rem per year) was found in a firm which handled approximately 200 Ci/a and had poor vault ventilation. Contamination was negligible in vaults at retail establishments.

The casing and repair areas of a firm which handled more than 100 Ci/a had air, surface, and human contamination values of 0.063 pCi/cm^3, 11,200 pCi/100 cm^3, 0.48 μCi/liter, and 0.039 pCi/cm^3, 7,820 pCi/100 cm^2, and 0.22 μCi/liter, respectively, on a yearly average. The casing and repair areas of a firm which handled about 10 Ci/a had air, surface, and human contamination values of background, 430 pCi/100 cm^2 and 0.08 μCi/liter, and background, 807 pCi/100 cm^2, and 0.05 μCi/liter, respectively, on a yearly average.

A refinisher who handled an estimated 30-50 Ci/a had air, surface, and human contamination values of background, 33,600 pCi/100 cm^2 (near stripping solution), and background, respectively, on a yearly average.

In the New York Metropolitan Area there are about 40 firms manufacturing, importing, and distributing self-luminous watches containing tritium. In plants belonging to these firms there are various areas where employee exposure to tritium may exist. Specifically, in a manufacturing plant, exposure areas include areas for mixing the tritiated compound with phosphor and adhesive (usually the phosphor is mixed with tritium in one plant and the adhesive is added to the mixture in a different plant at the time the paint is to be applied) and areas for painting watch hands and dials. Based on studies by others (*1-2*) and our own experience, there is no doubt that at the manufacturing stage, significant employee exposures can occur.

Less well known are the exposures to employees in other steps of the self-luminous watch industrial cycle (figure 1). For reasons of commerce, components of watches are imported into the United States primarily in the New York City area and assembled or cased into complete watches. The watches are then stored and distributed later to retailers throughout the country. Occasionally, at the consumer level, watches are returned for repair. At the end of the cycle some watches are returned to firms that specialize in refinishing the watch dials and hands according to customer specifications. Self-luminous watches at the present time may contain radium, tritium, or promethium-147 when they are returned, but they are usually repainted with radium.

All firms handling more than 2,000 self-luminous watches (representing about 2-10 Ci of tritium) at any one time are required to possess a radioactive materials license for possession and use of tritium.

This report covers studies that were conducted in watch storage, casing, repair, and refinishing areas. The survey techniques used in these areas were designed to determine the tritium surface and air contamination and human exposures. Surface contamination was determined by wiping an area of approximately 100 cm^2 with a Whatman No. 42 filter

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[1] New York State Department of Labor, Division of Industrial Hygiene, 80 Centre Street, New York, N.Y. 10013.

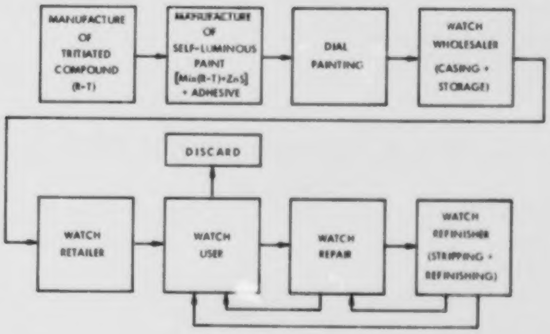
MANUFACTURE OF TRITIATED COMPOUND (R-T)
MANUFACTURE OF SELF-LUMINOUS PAINT [Mix(R-T)+ZnS] + ADHESIVE
DIAL PAINTING
WATCH WHOLESALER (CASING + STORAGE)
DISCARD
WATCH RETAILER
WATCH USER
WATCH REPAIR
WATCH REFINISHER (STRIPPING + REFINISHING)

Figure 1. Industrial cycle for a self-luminous watch

paper (approximate area 6.2 cm²). Particulate and tritiated water vapor contamination was determined by drawing air, first through a filter paper, and then through two midget impingers containing 10 ml of water each. Human tritium exposure was determined by collecting urine samples from employees. All samples were analyzed for their tritium content using the standard liquid scintillation counting technique (*3*).

Watch storage areas

In the first phase of the study, the storage vaults of 11 firms were checked three times in an 11-month period. Table 1 summarizes the results from the checks; the first nine listed firms are wholesale-importers, the last two are retailers. Firm X handled approximately 40,000 watches annually which represents about 200 Ci of tritium. The average surface contamina-

Table 1. Results of storage area survey

Firm	Date	Number of self-luminous watches on hand	Tritium activity on hand (Ci)	Number of self-luminous watches handled yearly	Surface activity $\left(\frac{\text{pCi}}{100\ \text{cm}^2}\right)$	Air concentration[a] $\left(\frac{\text{pCi}}{\text{cm}^3}\right)$	Resuspension factor[b] ($\times 10^{-2}\ \text{cm}^{-1}$)	Room ventilation[c]
X	Oct 1966	15,000	84	40,000	576	2.13	37	
	Jan 1967				2,076	2.05	9.85	
	Aug 1967	10,000	56		594	.621	10.4	
I	Oct 1966	30,000	30		3,308	.066	.20	Poor
	Jan 1967				3,825	.110	.28	
	Aug 1967	30,000	30		291	.138	4.7	
IV	Oct 1966	2,000	5	40,000	381	.097	2.54	Good
	Jan 1967				904	.194	2.14	
	Aug 1967	10,000	25		198	.512	26	
IX	Oct 1966	2,000	6	6,300	462	.140	3.0	Poor
	Jan 1967				557	.367	6.6	
	Aug 1967	1,500	4.5		850	.122	1.44	
VIII	Oct 1966	5,315	2.7		<1.73	Background		None
	Jan 1967				12.8	.0439	34.4	
	Aug 1967	4,400	2.2		<2.06	.0436	>212	
II	Oct 1966	2,850	2.0		356	.077	2.16	Poor
	Jan 1967				574	.168	2.93	
	Aug 1967	2,850	2.0		201	.310	15.5	
III	Oct 1966	600	.48		2,764	Background		Good
	Jan 1967				2,730	.179	.656	
	Aug 1967	1,500	1.2		696	.150	2.16	
VI	Oct 1966	100	.03	4,000	6.0	Background		Good
	Jan 1967	3,000	.96		38.3	Background		
	Aug 1967	500	.16		6.7	Background		
XI	Oct 1966	50	.25	300	152	.093	6.1	Good
	Jan 1967				84.0	.133	15.8	
	Aug 1967	300	1.5		48.8	.156	32.1	
VII	Oct 1966	2,000			4.6	.031	67	None
	Jan 1967	0			5.9	Background		
	Aug 1967							
V	Oct 1966	100			9.1	Background		None None
	Jan 1967				4.2	.0340	80	
	Aug 1967	100			<2.06	.0356	>173	(open area)

[a] Air concentration classified as background unless it is equal to or greater than the background plus 3σ value for the Tri-Carb counter (outside the 99.9 percent confidence band around counter background).

[b] $\text{Resuspension factor} = \frac{\text{air concentration in pCi/cm}^3}{\text{surface concentration in pCi/cm}^2}$.

[c] None–no mechanical ventilation provided. Poor–mechanical ventilation provided, but air flow across vault entrance less than 10 linear feet per minute. Good–mechanical ventilation provided, and air flow across vault entrance greater than 10 linear feet per minute.

tion varied from 576 pCi/100 cm² to 2,076 pCi/100 cm². The air concentration for the October 1966 survey was 2.13 pCi/cm³ and for the January 1967 survey, 2.05 pCi/cm³, which were the highest air concentrations observed during the study. In August 1967, the air concentration was 0.62 pCi/cm³ and the number of watches in storage was down from 15,000 in October 1966 to 10,000. The total tritium activity on hand at the time of the survey ranged from 84 Ci in October 1966 to 56 Ci in August 1967. Initially, a survey was conducted during the summer months because greater air and surface contamination was thought probable due to the generally high humidity at that time of year. The vault ventilation was rated as poor in this firm.

Firm I had on hand 30,000 watches or 30 Ci of tritium during the October 1966 and August 1967 surveys, but the firm did not know precisely how many self-luminous watches were handled on an annual basis. The average surface activity in the vault ranged from 291 pCi/100 cm² to 3,825 pCi/100 cm² and the air concentration ranged from 0.066 to 0.138 pCi/cm³, considerably lower than Firm X. The ventilation in this vault was rated good and certainly contributed to the lower air concentration in addition to the lower total activity on hand at the time of the survey as compared to Firm X. The remaining nine storage areas which were surveyed handled less activity and had less surface activity, although Firm III, reporting only 600 watches (representing a total activity of 0.5 Ci of tritium) on hand during the October 1966 survey, had an average surface activity of 2,764 pCi/100 cm² at that time. The air concentration for this firm varied from background in October to 0.179 pCi/cm³ in January 1967.

Urine samples were obtained from persons working in the vaults at several firms, and based on average tritium excretion values, estimated annual dose equivalents were calculated. Table 2 summarizes these dose estimates.

In all cases, the firms handling less than 2,000 watches had air concentrations less than 0.5 pCi/cm³, which is the International Commission on Radiation Protection's (ICRP) recommended value for an uncontrolled area, and surface contamination values ranged from 4 to 2,800 pCi/100 cm². Resuspension factors in units of pCi/cm³ per pCi/cm² ranged from 2×10^{-3} cm⁻¹ to >2 cm⁻¹. As one might expect these values are considerably higher than those found with nonvolatile plutonium compounds reported by Jones and Pond (4). Resuspension factors in that study ranged from 2×10^{-10} to 5×10^{-7} cm⁻¹.

Table 2. Annual dose equivalent estimated for persons working in storage areas

Firm	Survey period 1967	Excretion rate $\left(\frac{\mu Ci}{liter}\right)$	q[a] (μCi)	D[a] $\left(\frac{mrem}{week}\right)$	D (mrem/a)
X	January	[b] 4.39	[b] 157	[b] 15.7	
	August	.995	35.5	3.55	
				[c] 9.7	500
I	August	.806	28.8	2.88	(d)
IV	January	.184	6.57	.657	
	August	.463	16.5	1.65	
				[c] 1.16	60
III	January	.189	6.75	.675	
	August	.161	5.75	.575	
				[c] .625	33
XI	January	[b] .0865	[b] 3.09	[b] 3.09	
	August	.244	8.7	.870	
				[c] .59	31

[a] Assumes 28 μCi/liter is equivalent to q = 1,000 μCi and D = 100 mrem/week.

[b] Average of two persons.

[c] Average.

[d] No estimate made due to insufficient data.

As with many real life studies of this type there was observed in the variables studied a considerable range and general lack of correlation among the variables. Specifically, as table 1 indicates, there is no consistent correlation between tritium air and surface contaminations. But if one combines the total tritium activity on hand, the vault ventilation and the ability of tritium to exchange with stable hydrogen, especially in the water molecule, some of the apparent discrepancies are at least plausible.

Watch casing, repair, and refinishing areas

Table 3 gives the average tritium surface contamination observed in various areas in a sample of 21 firms which were inspected over a period of 1 year. Average surface contamination values ranged from 41 to 54,200 pCi/100 cm² with the greatest contamination generally observed in the casing area. The nature of the workload in the various areas in the watch firms with a mix of non-self-luminous and self-luminous watches makes it extremely difficult

Table 3. Results of surface wipe survey

Firm	Average surface activity $\left(\frac{\text{pCi}}{100\ \text{cm}^2}\right)$			
	Casing area	Repair area	Packing area	Quality control area
19	54,200			
	7,020			
	2,380			
13	9,760	2,690		
	2,820	160		
9	9,210	6,430		922
14	5,820			
6	4,660			
2	2,010			
15	1,740	5,390		
3	1,560			
11	1,480			
12	1,400			
8	1,100	363		
21	720		45	
1	639	4,000		
17	628			
4	591		1,030	
10	451			
7	413	843		
20	301			
5	296			
18	85			
16	41			

and impractical to segregate work areas in the radiation sense into controlled and uncontrolled areas. Therefore, surface contamination guidelines for uncontrolled areas must be met.

Based, at least partially, on the results of the watch storage area phase of the study, a guideline for tritium surface contamination in uncontrolled areas was established at 1,000 pCi/100 cm^2 average and 5,000 pCi/100 cm^2 maximum.

One notices from table 3 that two repeat visits were required to get Firm 19 down to 2,000 pCi/100 cm^2 average which was still a factor of two above the guideline.

While the tritium surface contamination guideline is 10 times the guideline in use by the New York State Department of Labor for all other beta-gamma emitters, there were still 13 firms (62 percent) above the guidelines. Tritium decontamination is a problem with some cleaned areas ending up with higher surface activity than before the cleaning. In addition, due to tritium's low radiotoxicity, it is possible that the guidelines may be set too low.

The next phase in the study was conducted in three firms over a 12-month period in an effort to correlate the surface, air, and urine excretion values. No special attempt was made to change handling procedures during this phase of the study but firms had removed the green felt pads, which are the hallmark of a watchmaker, from the workbenches because the pad was an obvious source of tritium accumulation.

Watch casing and repair areas

Two watch importers, designated Firm A and Firm B, were surveyed monthly over a 1 year period. In each firm, the casing and repair areas were checked.

In the casing area of Firm A, 15 persons were employed to perform two operations. One operation involved the insertion of a watch movement into a watch case; 100 watches were cased per man per day. The other operation in the same area involved the repair of new watches; 20–25 watches were handled per man per day. Approximately 23 percent of the watch line handled by Firm A is self-luminous and 142 curies were handled per year in the casing area during 1969. Each individual work area was cleaned daily with a sponge. The average surface activity for the 12-month period was 11,200 pCi/100 cm^2. The survey results are summarized in table 4 and plotted in figure 2 on a semi-logarithmic scale. The log scale was necessary due to the extremes in the activity found. In figure 2, the floor and table surface activities are plotted separately with the table showing the highest activity. This is not surprising since hot spots, presumably arising from specks of self-luminous material flaking off the watches, are to be expected. The average air concentration during the same period was 0.058 pCi/cm^3, which is 11.6 percent of the maximum permissible air concentration for uncontrolled areas. Urine samples were collected from two persons, and analysis of the samples yielded an average value of 0.48 μCi/liter, which is 17.3 percent of the permitted value for persons working in uncontrolled areas. Resuspension factors ranged from 3.3×10^{-4} to 2.0×10^{-3} cm^{-1}, a factor of 10-1,000 lower than was observed in the storage area.

In the repair area for used watches, 43 watchmakers were employed. It was estimated that a total of 137 curies of tritium activity was handled per year. The individual work

Table 4. Survey results of casing area, Firm A

Time	Average surface activity $\left(\frac{pCi}{100\ cm^2}\right)$	Air concentration $\left(\frac{pCi}{cm^3}\right)$	Resuspension factors (cm^{-1})	Excretion value $\left(\frac{\mu Ci}{liter}\right)$
May 1969	5,380	0.087	1.62×10^{-3}	0.51
June 1969	8,170	.108	1.32×10^{-3}	.47
July 1969	4,770	.097	2.03×10^{-3}	.28
August 1969	20,900	.091	4.35×10^{-4}	.44
September 1969	3,420	[a] .037	—	.52
October 1969	1,720	[a] .030	—	.60
November 1969	17,700	[a] .010	—	.64
December 1969	11,400	.103	9.03×10^{-4}	.47
January 1970	18,400	.060	3.26×10^{-4}	.47
February 1970	26,400	[a] .005	—	.47
March-April 1970	4,880	[a] .006	—	.45
Average	11,200	.058	—	.48
Percent of maximum permissible concentration	[b] 11.2	11.6		17.3

[a] Within background plus 3σ.
[b] See text, page 608, for explanation.

Table 5. Survey results of repair area, Firm A

Time	Average surface activity $\left(\frac{pCi}{100\ cm^2}\right)$	Air concentration $\left(\frac{pCi}{cm^3}\right)$	Resuspension factors (cm^{-1})	Excretion value $\left(\frac{\mu Ci}{liter}\right)$
May 1969	3,500	0.062	1.76×10^{-3}	0.30
June 1969	15,100	.059	3.9×10^{-4}	.28
July 1969	2,660	.078	2.93×10^{-3}	.19
August 1969	4,260	.055	1.29×10^{-3}	.22
September 1969	26,900	[a] .011	—	.26
October 1969	902	[a] .025	—	.19
November 1969	3,560	[a] .009	—	.22
December 1969	1,370	.083	6.08×10^{-3}	.19
January 1970	8,940	[a] .024	—	.21
February 1970	16,000	.011	—	.16
March-April 1970	2,860	[a] .014	—	.23
Average	7,820	.039		.22
Percent of maximum permissible concentration	[b] 7.8	7.8		7.9

[a] Within background plus 3σ.
[b] See text, page 608, for explanation.

benches were cleaned, in most cases daily, and there was a general weekly cleanup with disinfectant. The annual average surface activity was 7,820 pCi/100 cm² and the monthly values are summarized in table 5. The surface activity results are plotted in figure 3. The month-to-month variation was less on the floor compared with the activity noted on the tables. The least variation was found in the average urine excretion value, which is 0.22 μCi/liter for the survey period. Since the body acts to integrate and smooth out the exposure, the smaller variations are to be expected. The average air concentration was 0.039 pCi/cm³, slightly above background and 7.8 percent of the maximum recommended value. Resuspension factors ranged from 3.9×10^{-4} to 6.1×10^{-3} cm⁻¹.

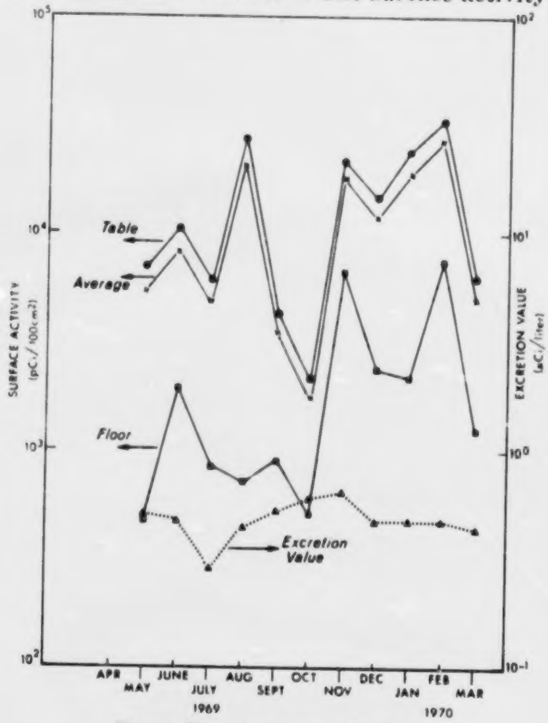

Figure 2. Casing area, Firm A

Firm B employed a varying number of people in the casing area. The number of people employed ranged from a high of 18 during the May through December 1969 period to a low of 12 in the slack period from January through March 1970. The total activity of tritium handled was approximately 10.5 curies per year. Between 5 to 10 percent of the watches contained tritium. Workbenches were washed weekly and floors cleaned once per month. The average surface activity over the 12-month period was 430 pCi/100 cm² and the average excretion value for 2 persons was 0.08 μCi/liter. The monthly results are given in table 6 and plotted in figure 4. The air concentration was at background. When they could be calculated, resuspension factors varied from 6.7×10^{-3} cm⁻¹ to 4.9×10^{-2} cm⁻¹.

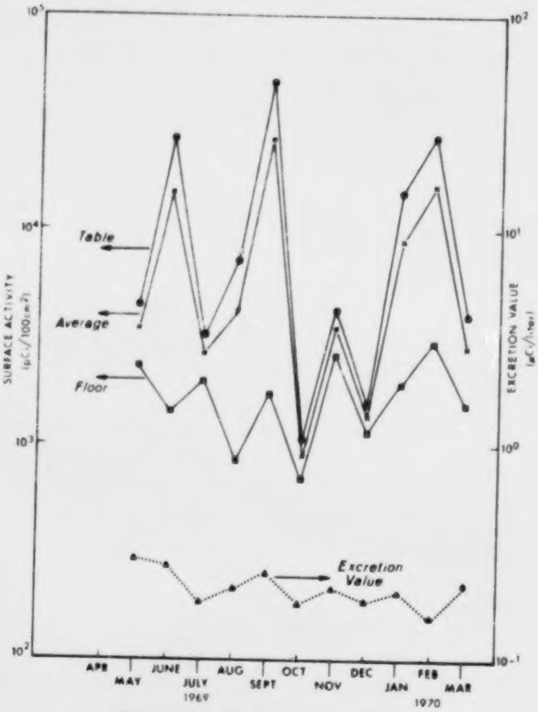

Figure 3. Repair area, Firm A

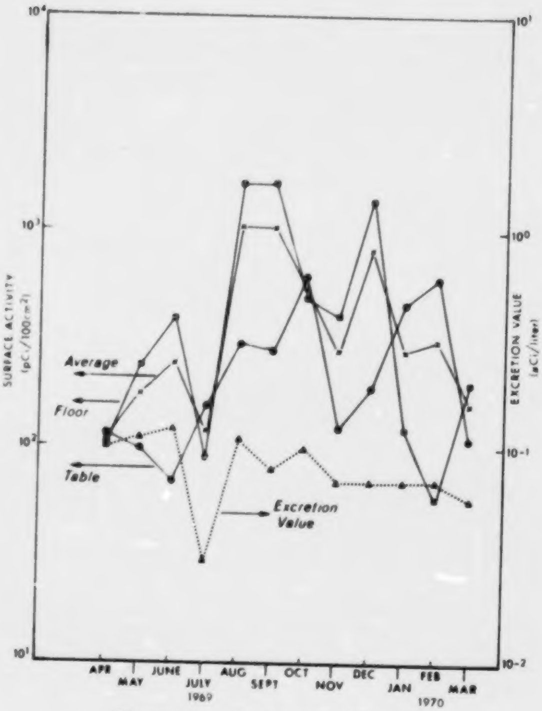

Figure 4. Casing area, Firm B

In the repair area, employment during the study period varied between a minimum of 17 to a maximum of 25 watchmakers. The total tritium activity handled in this area was estimated to be about 7.5 curies per year. Benches were cleaned twice per week and floors once per month. The average surface activity was 807 pCi/100 cm² and the average excretion value over the 12-month period was 0.05 µCi/liter which is 1.8 percent of the maximum permissible value. The monthly values are given in table 7 and plotted in figure 5. The air concentration was background in all but the month of December 1969. A resuspension factor of 1.6 × 10^{-2} cm^{-1} was calculated for the December 1969 visit.

Table 6. Survey results of casing area, Firm B

Time	Average surface activity $\left(\frac{pCi}{100\ cm^2}\right)$	Air concentration $\left(\frac{pCi}{cm^3}\right)$	Resuspension factors (cm^{-1})	Excretion value $\left(\frac{\mu Ci}{liter}\right)$
April 1969	110	0.042	3.82×10^{-3}	0.10
May 1969	174	[a] .027	—	.11
June 1969	243	[a] .001	—	.12
July 1969	120	.059	4.92×10^{-3}	.03
August 1969	1,050	[a] .026	—	.11
September 1969	1,030	[a] .006	—	.08
October 1969	557	[a] .002	—	.10
November 1969	279	.002	—	.07
December 1969	841	.056	6.66×10^{-3}	.07
January 1970	283	[a] .027	—	.07
February 1970	319	[a] .014	—	.07
March 1970	159	[a] .004	—	.06
Average	430	Background		0.08
Percent of maximum permissible concentration	[b] 0.4			2.9

[a] Within background plus 3σ.
[b] See text, page 608, for explanation.

The great difference in surface activity between Firms A and B can be attributed to the amount of tritium handled per year. Firm A, which handled more than 10 times the activity handled by Firm B per year, had an average surface activity more than 10 times the average surface activity of Firm B.

Watch refinishers

At the end of the watch cycle there exist firms which strip off the paint on the watch dial and hands and redecorate them according to customers' specifications. The dials and hands

Table 7. Survey results of repair area, Firm B

Time	Average surface activity $\left(\frac{pCi}{100\ cm^2}\right)$	Air concentration $\left(\frac{pCi}{cm^3}\right)$	Resuspension factors (cm^{-1})	Excretion value $\left(\frac{\mu Ci}{liter}\right)$
April 1969	647	[a] 0.004	—	0.04
May 1969	354	[a] .010	—	.06
June 1969	4,390	[a] .021	—	.02
July 1969	362	[a] .010	—	.03
August 1969	312	[a] .008	—	.04
September 1969	799	[a] 0	—	.05
October 1969	396	[a] .01	—	.04
November 1969	316	[a] .006	—	.06
December 1969	356	.056	1.57×10^{-3}	.09
January 1970	429	[a] .022	—	.04
February 1970	600	[a] .012	—	.07
March 1970	724	[a] .011	—	.06
Average	897	Background		.05
Percent of maximum permissible concentration	[b] 0.8			1.8

[a] Within background plus 3σ.
[b] See text, page 608, for explanation.

are placed in a small tray of paint remover whose composition varies among firms. It is a lye solution in one firm, acetone in another firm, and, at the firm studied on a monthly basis, a paint solvent solution. After a soaking period, the dials and hands are removed, dried and refinished. The paint removal operation is called stripping. In the firm studied (Firm C) seven employees came in contact with the dials and hands up to and including the stripping operation. A crude estimate gave a value of 30-50 curies of tritium handled per year.

The surface activity averaged 33,600 pCi/100 cm² for the room in which the stripping was done. This value is biased and does not truly represent the room average since the number of smears taken was small and concentrated around the stripping solution. Because this room had an approximate volume of 2.3×10^8 cm³ (8,000 ft³) the air concentration was background in most months except in two instances when high filter paper particulate activity was noted but little activity was found in the impingers. The urine excretion value was also near background for the person doing the stripping. Other areas in the plant, such as the refinishing room and machine shop, had negligible average surface activity.

Despite some hot spots, as indicated by the high smear values, the level of radiation from self-luminous tritium watches now being refinished does not represent any hazard to the worker at this time.

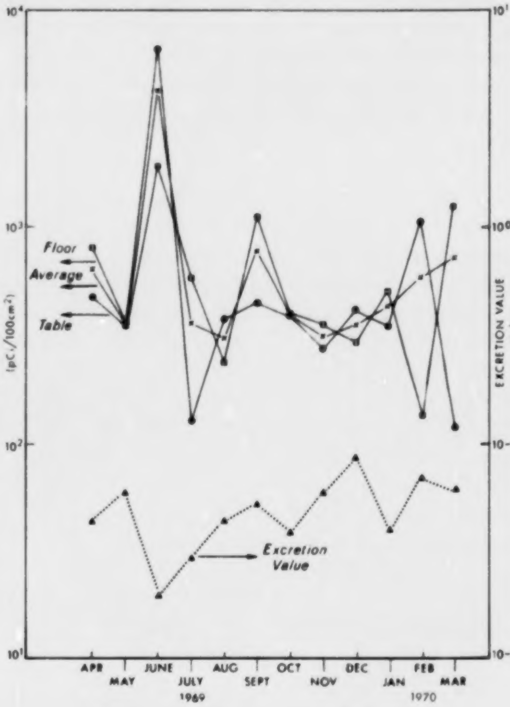

Figure 5. Repair area, Firm B

Removable surface contamination guidelines for uncontrolled (inactive) areas

The dilemma and pitfalls posed by setting surface contamination guidelines are well illustrated by this study. In the storage area survey, high tritium air concentration values were observed relative to the surface contamination values. This resulted in high resuspension values which ranged from 2×10^{-3} cm⁻¹ to >2 cm⁻¹, while in the casing and repair areas relatively high surface contamination values did not lead to high air or human contamination values. The resuspension values were also lower, ranging from 3.3×10^{-4} cm⁻¹ to 4.9×10^{-2} cm⁻¹. Therefore, the surface contamination guideline of 1,000 pCi/100 cm² average and 5,000 pCi/100 cm² maximum, which was established partly on the basis of the storage area survey, was quite adequate in the casing and repair areas.

While other investigators (*5-6*) have detailed the problems associated with defining and setting surface contamination limits, most of their remarks and investigations involved controlled areas. Our efforts were directed towards guidelines that would be applicable to uncontrolled areas or "inactive" areas. Dunster (*7*) has attempted to establish along more or less empirical lines surface contamination guidelines for both controlled and uncontrolled areas. He came to the conclusion that the limiting factor was dose to the skin from deposited radionuclides. But to date, no generally accepted model has arisen similar to the air and water exposure models. Consequently, several different sets of limits have been published and are summarized in table 8. One can construct a model wherein the activity representing the maximum permissible body burden is spread uniformly over 100 square feet (9.3 $m^2 \approx 10^5$ cm^2) to yield a maximum permissible surface activity. This model has the advantage of dependency on a radionuclide and permits the use of the standard practice of going from controlled area limits to uncontrolled area limits by dividing the controlled area limits by 10. The model yields a tritium maximum permissible surface contamination value of 100,000 pCi/100 cm^2 for an uncontrolled area.

In the watch casing and repair areas there appeared to be a correlation between surface, air and human contamination values. For the casing area in Firm A, these percentages were 11.2 percent, 11.6 percent and 17.3 percent of the maximum permissible values. In the repair area in Firm A, the percentages were 7.8 percent, 7.8 percent and 7.9 percent of the maximum permissible values. In these areas there were few watches in storage and the ventilation was good. Therefore, most of the air contamination probably arose from surface contamination and the correlation should not be too surprising since all of the limits are ultimately based on the tritium occupational maximum permissible body burden of 1 mCi. On the other hand, the watch storage facilities showed no correlation between surface, air, and human contamination. For Firm X, the percentages were 1.1 percent, 320 percent and 100 percent of the maximum permissible values. The general disagreement can be explained by the fact that the source of the air contamination was not primarily from surface activity but more likely from the tritium on the watches in storage. The ventilation in this facility was poor, thereby permitting a buildup in air activity from this source.

As indicated in table 8, there are two limits for alpha emitters in many jurisdictions. One set applies to alpha-emitting radionuclides of

Table 8. Some suggested removable surface contamination limits for uncontrolled areas

Radioactivity	Concentration $\left(\frac{\mu Ci}{cm^2}\right)$						
	British codes of practice[a]	AECL[a]	France CEA[a]	ORNL[a]	NCRP[b]	New York State Dept. of Labor	Based on MPBB model
Alpha emitters (very hazardous radionuclides)	10^{-5}	10^{-6}	10^{-5}	1.3×10^{-7}	4.5×10^{-7}	Average: 1.5×10^{-7} Maximum: 4.5×10^{-7}	
Alpha emitters (other radionuclides)	10^{-4}				4.5×10^{-6}		
Beta emitters (unspecified)	10^{-4}	10^{-5}	10^{-4}	4.5×10^{-6}	([c] 100)	Average: 1×10^{-6} Maximum: 5×10^{-6} (except for tritium)	
Beta emitters (tritium)						Average: 1×10^{-5} Maximum: 5×10^{-5}	1×10^{-3}

[a] As given in ICRP Publication 5 (1964) pp. 20–21.
[b] As given in NCRP Report No. 30 (NBS Handbook 92) (1965) table 6, p. 47.
[c] $\frac{cpm}{smear}$

low radiotoxicity, such as natural uranium and natural thorium, and the other value applies to all other alpha-emitting radionuclides. This is not the case with beta emitters where a single value is given which varies from 4.5×10^{-6} to 10^{-4} μCi/cm^2. (The British and French authorities sometimes list a separate value for very high-toxicity beta emitters but the value is identical to the value for other beta emitters.) The National Council on Radiation Protection and Measurements (NCRP) value of 100 cpm/smear is open to various interpretations. If one assumes the area covered by the smear is 100 cm^2 and a 50 percent geometry and efficiency factor, 100 cpm/smear is equivalent to 1×10^{-6} μCi/cm^2.

The guideline for surface contamination which we are using for all beta emitters, except tritium, is 1×10^{-6} μCi/cm^2 average and 5×10^{-6} μCi/cm^2 maximum. The inclusion of average and maximum values is more realistic than just one value. It is customary to estimate surface contamination by taking a number of smears over surfaces in the contaminated facility. The 1×10^{-6} μCi/cm^2 average and 5×10^{-6} μCi/cm^2 maximum surface contamination guidelines permit a realistic interpretation of such a survey. These values would be very difficult to live with in the case of tritium, therefore values of 10×10^{-6} μCi/cm^2 average and 50×10^{-6} μCi/cm^2 maximum were recommended for tritium. Although higher values might be justified in some cases, there are other situations, such as in a storage area, where a higher limit could be misleading.

While the results of this study indicate that monitoring an isolated parameter, such as surface contamination, could lead to misleading conclusions, it is still important to recognize that monitoring surface contamination is an important diagnostic tool in health physics. In checking on day-to-day operations it gives information on the location and source of contamination. It assists in identifying problem areas. It is a simple and relatively easy monitoring technique to use. In the case of tritium, if surface contamination is permitted to build up, there will be a gradual buildup in air activity as the tritium is covered over through cleaning, waxing and painting. Finally, at the time of vacating installations, surface contamination limits are required. Vacating facilities is not an infrequent occurrence in the industrial world; among licensed watch firms, it occurs about once per year. The final cleanup of facilities when they are vacated might be impossible to any realistic limit if the operation is not conducted under some type of surface contamination constraint. Past histories of decontamination operations have indicated many times that the real problem normally lies not with decontaminating the removable surface contamination but in reducing the fixed contamination. There is the additional possibility that too high surface contamination or even total lack of consideration of surface contamination will lead to the spread of activity to other areas via a person's hands, clothing, and shoes.

That the behavior of tritium is peculiar in the relationship between its surface and air contamination values is clearly shown in table 9. The table summarizes observed resuspension values for several radionuclides taken under a variety of conditions. The values for tritium are several orders of magnitude larger than those observed with all other radionuclides studied.

Table 9. Some resuspension factors reported in literature

Radionuclide	Conditions of measurement	Resuspension factor (cm^{-1})	Source
Uranium	Actual plant conditions	1.3×10^{-7}	Eisenbud, Blatz and Barry (*5*)
Plutonium oxide	Controlled experiments	$2 \times 10^{-10} - 5 \times 10^{-7}$	Jones and Pond (*4*)
Plutonium nitrate	Controlled experiments	$2 \times 10^{-10} - 5 \times 10^{-7}$	Jones and Pond (*4*)
Plutonium	Controlled experiment	$5 \times 10^{-7} - 1 \times 10^{-4}$	Glauberman, Bottman and Breslin (*6*)
Uranium	Controlled experiment	$2 \times 10^{-7} - 4.7 \times 10^{-6}$	Glauberman, Bottman and Breslin (*6*)
Unspecified	Actual plant conditions (new plant)	$2 \times 10^{-6} - 1 \times 10^{-5}$	Brunskill (*8*)
Unspecified	Actual plant conditions (small unventilated room)	4×10^{-5}	Brunskill (*8*)
Tritium	Actual plant conditions (storage vaults)	$2.0 \times 10^{-3} - > 2$	This paper
Tritium	Actual plant conditions (casing and repair rooms)	$3.3 \times 10^{-4} - 4.9 \times 10^{-3}$	This paper

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This might be partially explained on the basis of different sampling and averaging techniques but probably most of the difference arises from tritium, in storage or inaccessible to smear detection, interacting with water vapor in the air.

Summary

Storage vaults of 11 firms (nine wholesale-importer and two retailers) were surveyed three times over an 11-month period. A range of air, surface, and human contamination was found which depended on a variety of factors. The principal factors appeared to be the quantity of tritium in storage and the degree of ventilation in the vault. The highest human exposure was observed in an individual working in a poorly ventilated vault through which moved about 200 Ci of tritium annually. At the retail level, two storage areas had negligible contamination.

The casing and repair areas of two firms were surveyed monthly over a 12-month period. The firm handling 142 Ci of tritium on an annual basis in the casing area had an average surface contamination of 11,200 pCi/100 cm^2, but air and human contamination were a modest 0.058 pCi/cm^3 and 0.48 μCi/liter. The repair area of this firm, handling 137 Ci of tritium annually, had average surface contamination of 7,820 pCi/100 cm^2 but air and human contamination were a modest 0.039 pCi/cm^3 and 0.22 μCi/liter. The casing area of the firm handling 10.5 Ci of tritium annually had air, surface, and human contamination of background, 430 pCi/100 cm^2 and 0.08 μCi/liter, respectively. This firm handled 7.5 Ci of tritium in its repair area where air, surface, and human contamination was background, 807 pCi/100 cm^2 and 0.05 μCi/liter, respectively.

One watch refinisher was surveyed over a 12-month period. An estimate of 30-50 Ci of tritium annually was stripped off hands and dials. The area near the stripping solution had average surface contamination of 33,600 pCi/100 cm^2 but negligible air and human contamination was found.

To control the spread of tritium contamination and to head off future problems in tritium decontamination, surface contamination limits of 1,000 pCi/100 cm^2 average and 5,000 pCi/100 cm^2 maximum, were adopted.

Resuspension values found with tritium were in the range of 2.0×10^{-3} to >2 cm^{-1} for the storage area and in the range of 3.3×10^{-4} to 4.9×10^{-2} cm^{-1} for the casing and repair areas. The range of resuspension values are higher than those found with other radionuclides. The difference may be the result of different experimental techniques but may also be attributable to the buildup of tritium in the atmosphere as a result of the exchange of water vapor in the air with tritium on watches. This tritium is not accounted for in the usual definition of resuspension factor and may contribute to the higher values.

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Technical Notes

Consideration of Stable Iodine in the Environment in the Evaluation of Maximum Permissible Concentrations for Iodine-129

Jacob Tadmor[1]

In evaluating the hazards to man resulting from internal irradiation due to inhalation or ingestion of radioisotopes, only one pathway at a time is considered in presenting the maximum permissible concentrations (MPC). It is generally assumed that the physical, chemical, and biological behavior of the radioisotopes is similar to that of the corresponding stable elements. Much of the behavior of radioactive isotopes in an equilibrated environment (for instance, the extent of their assimilation and concentration in different organs of the human body) of limited content of the element could be influenced by the specific activity of the radionuclide, i.e., the ratio between the mass concentration of radioactive and total (radioactive and stable) isotopes present. This is especially true in the case of a routine and continuous release of radioisotopes to the environment. Therefore, in establishing the MPC for a radionuclide, it is important to consider the ratio between the concentrations of the radioactive and total isotopes in an environment in equilibrium with a source of a radionuclide release, i.e., in which all pathways by which a man may take in a radionuclide (air, water, food, etc.) are in equilibrium with it (*1*).

The specific activity concept in recommending maximum permissible concentrations of radionuclides has been suggested by the National Academy of Sciences (*2*) and applied by several authors (*3-7*).

In the present study, an example is presented showing the influence of the concentration of stable elements on the assimilation and concentration of radioactive material in the human body in an environment which is assumed to be in equilibrium with a source of a radionuclide release.

Evaluation of MPC's for radionuclides

Consideration of the relationship between the concentration of stable and radioactive isotopes in an equilibrated environment reveals that a revision of the MPC's established for certain radioisotopes may be in order.

Consider a radioisotope of which the mass concentration corresponding to the MPC is high relative to that of the stable element in the environment. Assume that the same ratio exists at equilibrium in the human body. This is true for radionuclides having a long half-life, so that the radioactive decay constant is negligible compared to the biological elimination constants in the food chains leading to human intake. Then, the actual radioisotope burden in the critical organ, following the establishment of an equilibrium state, may exceed the maximum permissible burden established by the radiation and MPC limitation. In this case, the MPC should be reduced according to the equilibrium ratio between the radioactive and total isotopes in the environment and critical organ. Consideration should also be given to the potential toxicological effects of an increased mass concentration of the element in the environment (*8*).

A test computation was performed on the MPC in air of iodine-129 and the corresponding maximum permissible burden in the thyroid, taking into consideration the ratio between the mass concentration of the radioactive and total isotopes.

Adams and Bonnell (*9*) and Colard et al. (*10*) have shown that ingestion of inorganic iodide would significantly reduce the dose to the thyroid due to concurrently inhaled radioactive iodine. It was also indicated (*10*) that the iodine-saturated thyroid gland will not take up more activity from a new feeding of iodide, which will be completely excreted by the kidneys. The possible influence of stable iodine on the rate of reaction and ultimate fate of radioactive iodine in the environment has also been discussed by Cowser (*11*). These results indicate that, because of the limited content of iodine in the thyroid, a relatively high mass concentration of radioactive iodine would reduce the amount of stable iodine, up to the saturation of the thyroid with radioactive iodine.

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[1] Professor Tadmor is with the Soreq Nuclear Research Centre, Yavne and the Department of Environmental Sciences, Tel-Aviv University, Tel-Aviv, Israel.

A continuous release of iodine-129 to the atmosphere may be envisaged following the expansion of the nuclear industry, mainly that of the nuclear fuel reprocessing plants. It is assumed (*12*) that a 10 tons/day fuel reprocessing plant is representative of the size which would be needed by the year 2000 in an area of high concentration of nuclear reactors. The release of iodine-129 from the reprocessing without any separation factor would be 0.33 Ci/day for a burnup of 20,000 Mwd/ton (*13*). In order to stress the need of ensuring efficient removal of iodine-129 from stack gases, it is assumed, for illustrative purposes, that about 90 percent of the iodine-129 contained in spent nuclear fuel is released to the atmosphere in a nuclear fuel reprocessing plant (*14*). Assuming a release of iodine-129 at a height of 50 m, the average annual concentration in the environment, along a 22.5° arc, at the region of maximum concentration (1 to 5 km) would be of the order of 10^{-11} Ci/m^3 (*15*), which approaches the nonoccupational (168 h-week) MPC in air for iodine-129, i.e. 6×10^{-11} Ci/m^3 (thyroid as critical organ). The nonoccupational MPC in air is considered as 1/10 of the occupational limit (*16, 17*).

Assume that the environment of a fuel reprocessing plant has a continuous air concentration of iodine-129 equal to 6×10^{-11} Ci/m^3. The specific activity of iodine-129 is 1.6×10^{-4} Ci/g (6.24×10^3 g/Ci). Thus, the iodine-129 mass concentration corresponding to the MPC is 3.7×10^{-7} g/m^3. Together with iodine-129, stable iodine is also released from nuclear fuel reprocessing plants. The ratio of ^{129}I/^{127}I in spent fuel, after 1 year cooling, being 0.75, the concentration of stable iodine at the region of maximum concentration would be of the order of 10^{-7} g/m^3.

This concentration of stable iodine in air is assumed to be representative for otherwise unpolluted air and is taken for illustrative purposes, although a wide variability of concentrations is encountered in different areas. Thus, a concentration of 5×10^{-9} g/m^3 is indicated for unpolluted air (*18*), while a range of 0 to 7×10^{-8} g/m^3 is indicated by others (*19*) for the concentration of stable iodine. For other specific values of stable iodine concentrations, different from that assumed in the present study, the calculations should be made using the local data of the individual cases.

Considering a long-lived radioisotope such as iodine-129 being released continuously to the atmosphere, it is assumed that, at environmental equilibrium established after long-time release of iodine-129, the ratio between iodine-129 and total iodine as found in air would exist also in other pathways by which man may take in a radionuclide.

Iodine-129, being continuously released to the environment, is also being deposited on surface water, soil, and vegetation, which become equilibrated with the iodine of the atmosphere (*20, 21*). Table 1 shows the half time to equilibrium for iodine-129 via different pathways and for various human tissues, as compiled by Pratt (*21*). It was also found (*22*) that the delay between the appearance of a peak in vegetation and its appearance in milk is only several days, and that fresh milk is one of the principal modes of intake of radioiodine in an area where relatively high concentrations of the radioiodine exist. Moreover, a "reconcentration factor" or rather an MPC$_a$ reducing factor of up to 700 is recommended (*23-25*) for radioactive iodine, when considering the pasture deposition—milk exposure pathway.

Similarly to milk, other pathways of iodine intake in man are also assumed to be equilibrated with the iodine in the atmosphere. Thus, Russell and Hahn (*26*) indicated that a weed sample collected in Cattaraugus Creek, about 1 mile downstream of Nuclear Fuel Services

Table 1. Half time to equilibrium for iodine-129 in various pathways

Pathway	Organ	Half time to equilibrium (days)	
		Adult	Child
Sea water and fresh water	Bone	14	2
Milk	Bone	35	14
Milk	Whole body	167	14
Sea water and fresh water	Whole body	138	19.7
Soil	Bone and whole body	2.78×10^6	2.53×10^6

discharge contained 0.81 μCi ^{129}I/g of total iodine. This would cause about 10 percent of the Federal Radiation Council (FRC) guidance for the maximum dose to man's thyroid, assuming that the ratio of iodine-129 to stable iodine is at equilibrium throughout the chain. Also, Ng and Thompson (*27*) assumed, in a study of the radiation doses from internal emitters, that radionuclides deposited on ground and vegetation equilibrate fast within the biological exchangeable pool.

It is also assumed that all the iodine supply to the population, i.e., from air, as well as from food items such as milk, vegetables, etc., is provided by the environment nearby to the release source of iodine-129 (up to about 5 km), in which the ratio of iodine-129 concentration to that of total iodine is relatively high.

The average total iodine content in the normal thyroid is 7×10^{-3} g (*16*). Assuming that all pathways of intake of iodine are equilibrated with the iodine in the atmosphere, the thyroid would contain at equilibrium mostly (75 percent) iodine-129. Thus, its iodine-129 thyroid burden corresponding to the MPC would be:

$$(7.5 \times 10^{-1})\ (7 \times 10^{-3}\ \text{g})\ (1.6 \times 10^{-4}\ \text{Ci/g}) = 8.4 \times 10^{-7}\ \text{Ci}.$$

In comparison with the estimated thyroid burden of 8.4×10^{-7} Ci, the maximum permissible burden of iodine-129 in the total human body for the nonoccupational population (thyroid as critical organ), established by the radiation limit and MPC, is 3×10^{-7} Ci (*17*) and the corresponding thyroid permissible burden (considering $f_2 = 0.2$) is 6×10^{-8} Ci.[2]

It thus appears that, by establishing an MPC_a for iodine-129 of 6×10^{-11} Ci/m^3 for the nonoccupational population, the human thyroid burden would reach a level of about fourteenfold higher than the maximum permissible burden. Consequently, the nonoccupational MPC in air should be lowered to a value which would yield a fourteenfold reduction in the iodine-129 specific activity at equilibrium within the thyroid, i.e. 5.4 percent instead of 75 percent, so that the maximum permissible burden in the thyroid is not exceeded.

The corresponding iodine-129 burden in the thyroid would then be:

$$(7 \times 10^{-3}\ \text{g})\ (5.4 \times 10^{-2})\ (1.6 \times 10^{-4}\ \text{Ci/g}) = 6 \times 10^{-8}\ \text{Ci},$$ which is the thyroid permissible burden.

Assuming an average concentration of 10^{-7} g/m^3 of stable iodine in air and for a specific activity of 5.4 percent of iodine-129, the mass concentration of iodine-129 in air is calculated to be 5.4×10^{-9} g/m^3 and the corresponding activity concentration is 8.6×10^{-13} Ci/m^3, which should be the recommended reduced MPC.

A value of 8.4×10^{-13} Ci/m^3, similar to the MPC suggested in the present study for iodine-129 in air, is also calculated using the specific activity models proposed in references 2, 3, and 5.

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[2] f_2 = fraction of the radionuclide in the critical organ of that in total body.

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Strontium-90 and Cesium-137 in Canned Seafood, Taiwan, Republic of China, 1970–1971

P. S. Weng and Agnes P. L. Liu [1]

Since 1970, canned seafood available on the market has been regularly monitored for strontium-90 and cesium-137 radioactivity. Tsing Hua University analyzed the samples by means of standard radiochemical methods and beta-particle counting in a low, background counting system.

The samples included canned seafood from Europe, North America, Japan, and Taiwan as well as a wide variety of seafood extending from sardines to seaweeds. No exceptionally high radioactivity was detected during 1970-1971 period. The mean concentration of strontium-90 was 0.14 ± 0.03 pCi/g ash and that of cesium-137, 0.17 ± 0.05 pCi/g ash. The ratio cesium-137/strontium-90 was 1.21 ± 0.44. The results of the analyses are presented in table 1 and plotted in figure 1.

The table and figure show that there is no significant difference in the fallout content among the samples analyzed. As compared with fresh fish, such as neothunnus macropterus, white dorads, stromateoides argenteus, red snapper, dorade, and thunnus thynnus available in Taiwan, the gross beta radioactivity in canned fish (sardines, herrings, mackerels, salmon, pacific saury, maguro, tuna, and bonita) was 0.61 of that in fresh fish. In other words, the fresh sea fish contained more gross beta radioactivity in pCi/g ash than the canned seafood.

Other canned seafood, such as deep sea shellfish, snow crab meat, baked bloody clams skewered, ark shell, laver, top shells, and lobster, show a lower gross beta radioactivity than canned fish. The gross beta ratio of shellfish to fish is 0.33.

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[1] P. S. Weng and Agnes P. L. Liu are with the Health Physics Section, National Tsing Hua University, Hsinchu, Taiwan 300, Republic of China.

Table 1. Strontium-90 and cesium-137 levels in canned seafoods, 1970–1971

Sample number	Seafood and country of origin	Net weight wet (g)	Ash weight (g)	Potassium $\left(\frac{\text{mg}}{\text{100 mg ash}}\right)$	Cesium-137 $\left(\frac{\text{pCi}}{\text{g ash}}\right)$	Potassium-40 $\left(\frac{\text{pCi}}{\text{kg}}\right)$ (wet weight)	$\frac{^{137}\text{Cs}}{\text{K}}$ $\left(\frac{\text{pCi}}{\text{g}}\right)$	Calcium $\left(\frac{\text{mg}}{\text{100 mg ash}}\right)$	Strontium-90 $\left(\frac{\text{pCi}}{\text{g ash}}\right)$
1	Sardines, U.S.A.	425	12.3815	14.60	0.24 ± 0.16	4.25	6.99	4.89	0.18 ± 0.16
2	Deep sea shellfish, Mexico	855	18.8775	12.65	.18 ± .15	2.79	3.97	*.97	.16 ± .15
3	Sardines, Canada	96	2.6899	11.09	.18 ± .15	3.11	5.04	4.70	.14 ± .15
4	Herring, Germany	780	27.3177	14.02	.14 ± .16	4.91	4.90	4.37	.14 ± .15
5	Herring, United Kingdom	1,185	32.9485	7.87	.16 ± .15	2.19	4.45	5.22	.16 ± .15
6	Baby mackerel, Portugal	125	3.7842	14.71	.26 ± .15	4.45	7.87	4.53	.21 ± .16
7	Mackerel, Japan	425	9.9772	14.87	.26 ± .16	3.49	6.10	4.23	.16 ± .15
8	Snow crab meat, Japan	730	28.0061	4.48	.13 ± .15	1.72	4.99	4.51	.16 ± .15
9	Salmon, Japan	1,080	31.3788	14.17	.13 ± .16	4.11	3.78	6.59	.14 ± .16
10	Pacific saury, Japan	980	45.0898	4.37	.15 ± .15	2.01	6.90	3.52	.14 ± .16
11	Baked bloody clams skewered, Japan	1,000	29.4228	2.85	.11 ± .15	.84	3.24	*1.09	.13 ± .16
12	Mackerel, Japan	220	5.6444	13.06	.22 ± .15	3.35	5.64	4.09	.13 ± .15
13	Ark shell, Japan	890	30.0114	15.32	.15 ± .16	5.16	5.06	*1.26	.13 ± .15
14	Mackerel, Japan	220	5.9288	11.35	.20 ± .15	3.05	5.39	3.71	.12 ± .15
15	Maguro, Japan	280	8.3920	11.76	.19 ± .15	3.52	5.69	*1.40	.12 ± .16
16	Laver, Japan	1,200	43.1424	3.50	.11 ± .15	1.26	3.95	*.46	.11 ± .14
17	Laver and fish, Japan	1,095	39.8918	11.97	.11 ± .15	1.36	4.01	*.81	.11 ± .14
18	Top shells, Japan	1,100	36.5368	3.99	.11 ± .15	1.33	3.65	*.46	.11 ± .15
19	Tuna, Taiwan	200	3.9090	7.03	.16 ± .17	1.37	3.13	*.32	.10 ± .15
20	Lobster, Taiwan	520	39.7479	8.02	.13 ± .15	6.13	9.94	3.55	.13 ± .15
21	Tuna, Taiwan	200	4.8387	12.58	.20 ± .16	3.04	4.84	*.33	.15 ± .14
22	Bonito, Taiwan	870	25.2898	11.80	.25 ± .17	3.43	7.27	5.04	.20 ± .16

* Without bone.

Table 1. Strontium-90 and cesium-137 levels in canned seafoods, 1970–1971—continued

Sample number	Seafood and country of origin	Calcium $\left(\frac{g}{kg}\right)$ (wet weight)	Strontium-90 $\left(\frac{pCi}{kg}\right)$ (wet weight)	$\frac{^{90}Sr}{Ca}$ $\left(\frac{pCi}{g}\right)$	$\frac{^{137}Cs}{^{90}Sr}$	$\frac{^{90}Sr}{^{137}Cs}$	Gross beta $\left(\frac{pCi}{g\ ash}\right)$	Gross beta $\left(\frac{pCi}{g}\right)$ (wet weight)
1	Sardines, U.S.A.	1.42	5.24	3.69	1.33	0.75	113.74	3.31
2	Deep sea shellfish, Mexico	.21	3.53	16.81	1.13	.89	57.12	1.26
3	Sardines, Canada	1.32	3.92	2.97	1.28	.78	72.75	2.04
4	Herring, Germany	1.53	4.90	3.20	1.00	1.00	32.97	1.15
5	Herring, United Kingdom	1.45	4.45	3.07	1.00	1.00	82.21	2.29
6	Baby mackerel, Portugal	1.37	6.36	4.64	1.24	.81	126.80	3.84
7	Mackerel, Japan	.99	3.76	3.80	1.62	.62	132.21	3.11
8	Snow crab meat, Japan	1.73	6.14	3.55	.81	1.23	23.20	.89
9	Salmon, Japan	1.91	4.07	2.13	.93	1.08	25.76	.75
10	Pacific saury, Japan	1.62	6.44	3.98	1.07	.93	47.98	2.21
11	Baked bloody clams skewered, Japan	.32	3.83	11.97	.85	1.18	15.77	.46
12	Mackerel, Japan	1.05	3.34	3.18	1.69	.59	133.56	3.43
13	Ark shell, Japan	.42	4.38	10.43	1.15	.87	24.95	.84
14	Mackerel, Japan	1.00	3.23	3.23	1.67	.60	79.05	2.13
15	Maguro, Japan	.42	3.60	8.57	1.58	.63	67.57	2.03
16	Laver, Japan	.17	3.95	23.24	1.00	1.00	21.85	.79
17	Laver and fish, Japan	.30	4.01	13.37	1.00	1.00	19.59	.71
18	Top shells, Japan	.15	3.65	24.33	1.00	1.00	24.10	.80
19	Tuna, Taiwan	.06	1.95	32.50	1.60	.63	87.84	1.72
20	Lobster, Taiwan	2.71	9.94	3.67	1.00	1.00	28.29	2.16
21	Tuna, Taiwan	.08	3.63	45.37	1.33	.75	93.69	2.26
22	Bonito, Taiwan	1.46	5.81	3.98	1.25	.80	50.99	1.48

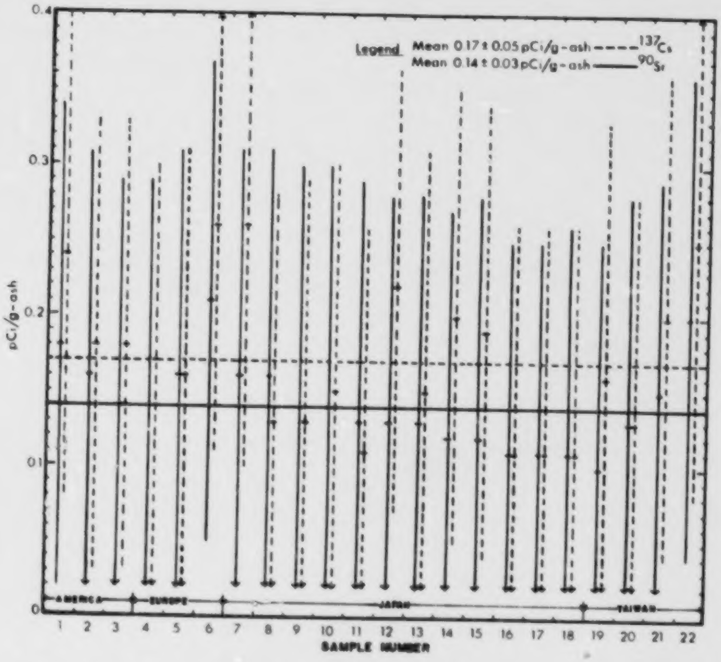

Figure 1. Strontium–90 and cesium–137 levels in canned seafood

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Data

SECTION I. MILK AND FOOD

Milk Surveillance, August 1971

Although milk is only one of the sources of dietary intake of environmental radioactivity, it is the food item that is most useful as an indicator of the general population's intake of radionuclide contaminants resulting from environmental releases. Fresh milk is consumed by a large segment of the population and contains several of the biologically important radionuclides that may be released to the environment from nuclear activities. In addition, milk is produced and consumed on a regular basis, is convenient to handle and analyze, and samples representative of general population consumption can be readily obtained. Therefore, milk sampling networks have been found to be an effective mechanism for obtaining information on current radionuclide concentrations and long-term trends. From such information, public health agencies can determine the need for further investigation or corrective public health action.

The Pasteurized Milk Network (PMN) sponsored by the Office of Radiation Programs, Environmental Protection Agency, and the Office of Food Sanitation, Food and Drug Administration, U.S. Public Health Service, consists of 63 sampling stations: 61 located in the United States, one in Puerto Rico, and one in the Canal Zone. Many of the State health departments also conduct local milk surveillance programs which provide more comprehensive coverage within the individual State. Data from 15 of these State networks are reported routinely in *Radiological Health Data and Reports*. Additional networks for the routine surveillance of radioactivity in milk in the Western Hemisphere and their sponsoring organizations are:

Pan American Milk Sampling Program (Pan American Health Organization and U.S. Environmental Protection Agency)—5 sampling stations
Canadian Milk Network (Radiation Protection Division, Canadian Department of National Health and Welfare)—16 sampling stations.

The sampling locations that make up the networks presently reporting in *Radiological Health Data and Reports* are shown in figure 1. Based on the similar purpose for these sampling activities, the present format integrates the complementary data that are routinely obtained by these several milk networks.

Radionuclide and element coverage

Considerable experience has established that relatively few of the many radionuclides that are formed as a result of nuclear fission become incorporated in milk (*1*). Most of the possible radiocontaminants are eliminated by the selective metabolism of the cow, which restricts gastrointestinal uptake and secretion into the milk. The five fission-product radionuclides which commonly occur in milk are strontium-89, strontium-90, iodine-131, cesium-137, and barium-140. A sixth radionuclide, potassium-40, occurs naturally in 0.0118 percent (*2*) abundance of the element potassium, resulting in a specific activity for potassium-40 of 830 pCi/g total potassium.

Two stable elements which are found in milk, calcium and potassium, have been used as a means for assessing the biological behavior of metabolically similar radionuclides (radiostron-

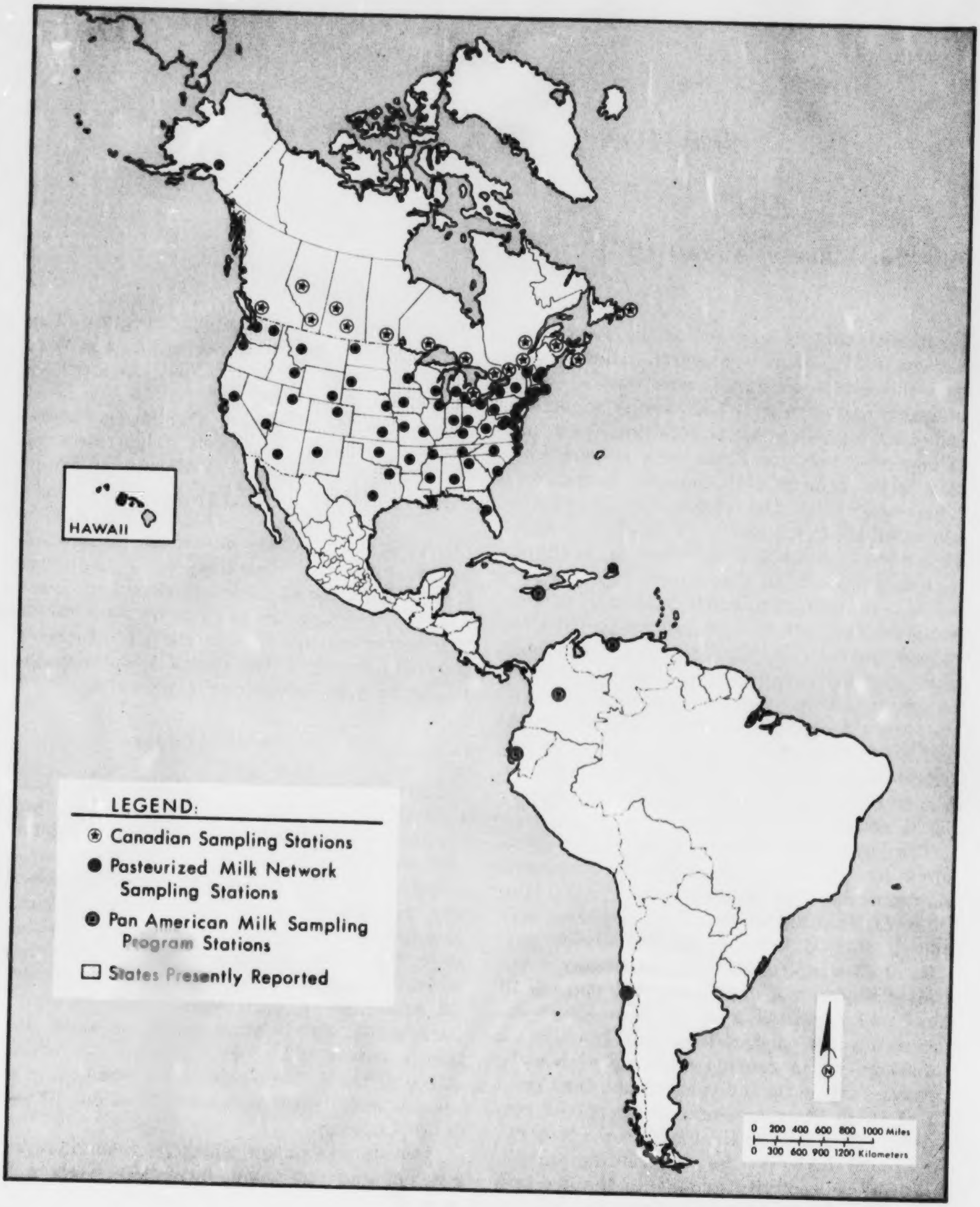
HAWAII
LEGEND:
⊛ Canadian Sampling Stations
● Pasteurized Milk Network Sampling Stations
◉ Pan American Milk Sampling Program Stations
☐ States Presently Reported
0 200 400 600 800 1000 Miles
0 300 600 900 1200 Kilometers
N

Figure 1. Milk sampling networks in the Western Hemisphere

tium and radiocesium, respectively). The contents of both calcium and potassium in milk have been measured extensively and are relatively constant. Appropriate values and their variations, expressed in terms of 2 standard deviations (2σ), for these elements are 1.16 ± 0.08 g/liter for calcium and 1.51 ± 0.21 g/liter for potassium. These figures are averages of data from the PMN for May 1963-March 1966 (*3*) and were determined for use in general radiological health calculations or discussions.

Accuracy of data from various milk networks

In order to combine data from the international, national, and State networks considered in this report, it was first necessary to determine the accuracy with which each laboratory is making its determinations and the agreement of the measurements among the laboratories. The Analytical Quality Control Service of the Office of Radiation Programs conducts periodic studies to assess the accuracy of determinations of radionuclides in milk performed by interested radiochemical laboratories. The generalized procedure for making such a study has been outlined previously (*4*).

The most recent study was conducted during May-July 1970, with 28 laboratories participating in an experiment on milk samples containing known concentrations of strontium-89, strontium-90, iodine-131, cesium-137, and barium-140 (*5*). Of the 18 laboratories producing data for the networks reporting in *Radiological Health Data and Reports*, 13 participated in the experiment.

The accuracy results of this experiment are shown in table 1. In general, considerable improvement is needed, especially in the accuracy measurements. These possible differences should be kept in mind when considering the integration of data from the various networks.

Development of a common reporting basis

Since the various networks collect and analyze samples differently, a complete understanding of several parameters is useful for interpreting the data. Therefore, the various milk surveillance networks that report regularly were surveyed for information on analytical methods, sampling and analysis frequencies, and estimated analytical errors associated with the data.

In general, radiostrontium is collected by an ion-exchange technique and determined by beta-particle counting in low-background detectors, and the gamma-ray emitters (potassium-40, iodine-131, cesium-137, and barium-140) are determined by gamma-ray spectroscopy of whole milk. Each laboratory has its own modifications and refinements of these

Table 1. Distribution of mean results, quality control experiment

Isotope and known concentration		Number of laboratories in each category			
		Acceptable[a]	Warning level[b]	Unacceptable[c]	Total
Strontium-89:	High (258 pCi/liter)	7 (44%)	1 (6%)	8 (50%)	16
	Low (15 pCi/liter)	11 (69%)	3 (19%)	2 (12%)	16
Strontium-90:	Intermediate (79.4 pCi/liter)	13 (57%)	4 (17%)	6 (26%)	23
	Low (32.0 pCi/liter)	5 (25%)	4 (20%)	11 (55%)	20
Iodine-131:	High (507 pCi/liter)	18 (67%)	2 (7%)	7 (26%)	27
	Low (49 pCi/liter)	16 (64%)	3 (12%)	6 (24%)	25
Cesium-137:	High (259 pCi/liter)	20 (74%)	3 (11%)	4 (15%)	27
	Low (53 pCi/liter)	17 (66%)	5 (19%)	4 (15%)	26
Barium-140:	High (302 pCi/liter)	18 (67%)	2 (7%)	7 (26%)	27
	Low (33 pCi/liter)	23 (92%)	0	2 (8%)	25

[a] Measured concentration equal to or within 2σ of the known concentration.
[b] Measured concentration outside 2σ and equal to or within 3σ of the known concentration.
[c] Measured concentration outside 3σ of the known concentration.

basic methodologies. The methods used by each of the networks have been referenced in earlier reports appearing in *Radiological Health Data and Reports.*

A previous article (*6*) summarized the criteria used by the State networks in setting up their milk sampling activities and their sample collection procedures as determined during a 1965 survey. This reference and an earlier data article for the particular network of interest may be consulted should events require a more definitive analysis of milk production and milk consumption coverage afforded by a specific network.

Many networks collect and analyze samples on a monthly basis. Some collect samples more frequently but composite the several samples for one analysis, while others carry out their analyses more often than once a month. Many networks are analyzing composite samples on a quarterly basis for certain nuclides. The frequency of collection and analysis varies not only among the networks but also at different stations within some of the networks. In addition, the frequency of collection and analysis is a function of current environmental levels. The number of samples analyzed at a particular sampling station under current conditions is reflected in the data presentation. Current levels for strontium-90 and cesium-137 are relatively stable over short-time periods, and sampling frequency is not critical. For the short-lived radionuclides, particularly iodine-131, the frequency of analysis is critical and is generally increased at the first measurement or recognition of a new influx of this radionuclide.

The data in table 2 show whether raw or pasteurized milk was collected. An analysis (*7*) of raw and pasteurized milk samples collected during January 1964 to June 1966 indicated that for relatively similar milkshed or sampling areas, the differences in concentration of radionuclides in raw and pasteurized milk are not statistically significant (*7*). Particular attention was paid to strontium-90 and cesium-137 in that analysis.

Practical reporting levels were developed by the participating networks, most often based on 2-standard-deviation errors or 2-standard-deviation total analytical errors from replicate analyses (*3*). The practical reporting level reflects analytical factors other than statistical radioactivity counting variations and will be used as a practical basis for reporting data.

The following practical reporting levels have been selected for use by all networks whose practical reporting levels were given as equal to or less than the given value.

Radionuclide	Practical reporting level (pCi/liter)
Strontium-89	5
Strontium-90	2
Iodine-131	10
Cesium-137	10
Barium-140	10

Some of the networks gave practical reporting levels greater than those above. In these cases, the larger value is used so that only data considered by the network as meaningful will be presented. The practical reporting levels apply to the handling of individual sample determinations. The treatment of measurements equal to or below these practical reporting levels for calculation purposes, particularly in calculating monthly averages, is discussed in the data presentation.

Analytical error or precision expressed as pCi/liter or percent in a given concentration range has also been reported by the networks (*3*). The precision errors reported for each of the radionuclides fall in the following ranges:

Radionuclide	Analytical errors of precision (2-standard deviations)
Strontium-89	1-5 pCi/liter for levels <50 pCi/liter; 5-10% for levels ≥ 50 pCi/liter;
Strontium-90	1-2 pCi/liter for levels <20 pCi/liter; 4-10% for levels ≥ 20 pCi/liter;
Iodine-131 Cesium-137 Barium-140	4-10 pCi/liter for levels <100 pCi/liter; 4–10% for levels ≥100 pCi/liter.

For iodine-131, cesium-137, and barium-140, there is one exception for these precision error ranges: 25 pCi/liter at levels <100 pCi/liter

Table 2. Concentrations of radionuclides in milk for August 1971 and 12-month period, September 1970 through August 1971

Sampling location		Type of sample[a]	Radionuclide concentration (pCi/liter)					
			Strontium-90		Iodine-131		Cesium-137	
			Monthly average[b]	12-month average	Monthly average[b]	12-month average	Monthly average[b]	12-month average
UNITED STATES:								
Ala:	Montgomery[c]	P	NA	7	0	0	15	10
Alaska:	Palmer[c]	P	5	5	0	0	22	13
Ariz:	Phoenix[c]	P	NA	1	0	0	0	0
Ark:	Little Rock[c]	P	16	12	0	0	0	11
Calif:	Sacramento[c]	P	NA	1	0	0	0	0
	San Francisco[c]	P	NA	4	0	0	0	0
	Del Norte	P	16	15	0	0	10	11
	Fresno	P	0	2	0	0	0	2
	Humboldt	P	NA		NA		NA	
	Los Angeles	P	0	2	0	0	0	0
	Mendocino	P	5	6	0	0	0	5
	Sacramento	P	3	3	0	0	0	2
	San Diego	P	0	1	0	0	0	1
	Santa Clara	P	2	2	0	0	0	1
	Shasta	P	3	3	0	0	10	4
	Sonoma	P	2	3	0	0	0	3
Colo:	Denver[c]	P	NA	4	0	0	0	6
	West	R	(d)		[e]0	[e]0	[e]0	[e]0
	Northeast	R	(d)		[e]0(2)	[e]0	[e]0(2)	[e]1
	East	R	(d)		NS	[e]0	NS	[e]0
	Southeast	R	(d)		NS	NS	NS	NS
	South Central	R	(d)		[e]0	[e]0	[e]0	[e]0
	Southwest	R	(d)		[e]0	[e]0	[e]0	[e]3
	Northwest	R	(d)		NS	[e]0	NS	[e]0
Conn:	Hartford[c]	P	NA	7	0	0	18	11
	Central	P	7	7	0	0	13	16
Del:	Wilmington[c]	P	NA	9	0	0	0	6
D.C:	Washington[c]	P	NA	7	0	0	12	9
Fla:	Tampa	P	5	5	0	0	38	45
	Central	R	8	6	0	0	11	36
	North	R	18	8	0	0	27	26
	Northeast	R	11	7	0	0	41	36
	Southeast	R	6	7	0	1	23	68
	Tampa Bay area	P	6	6	0	0	34	45
	West	R	11	10	0	0	12	17
Ga:	Atlanta[c]	P	NA	11	0	0	16	14
Hawaii:	Honolulu[c]	P	2	2	0	0	13	2
Idaho:	Idaho Falls[c]	P	7	5	0	0	0	6
Ill:	Chicago[c]	P	7	7	0	0	11	11
Ind:	Indianapolis[c]	P	NA	7	0	0	0	5
	Northeast	P	8	9	0	0	10	15
	Southeast	P	12	10	0	0	15	14
	Central	P	9	8	0	5	10	12
	Southwest	P	8	10	0	0	15	13
	Northwest	P	8	10	0	0	15	13
Iowa:	Des Moines[c]	P	NA	6	0	0	0	3
	Des Moines	P	9	7	0(5)	0	7(5)	11
	Iowa City	P	8	8	0	0	17	15
	Little Cedar	P	NS		NS		NS	
	Spencer	P	7	6	0	0	15	15
Kans:	Wichita[c]	P	NA	7	0	0	0	2
	Coffeyville	P	6	9	0	4	21	11
	Dodge City	P	5	7	0	0	10	5
	Falls City	P	5	3	0	3	10	9
	Hays	P	11	10	0	3	13	7
	Kansas City	P	7	6	6	5	10	14
	Topeka	P	10	10	0	3	10	11
	Wichita	P	7	11	0	1	13	10
Ky:	Louisville[c]	P	NA	9	0	0	14	4
La:	New Orleans[c]	P	17	14	0	0	31	20
Maine:	Portland[c]	P	NA	9	0	0	28	21
Md:	Baltimore[c]	P	NA	8	0	0	11	7
Mass:	Boston[c]	P	8	9	0	0	13	17
Mich:	Detroit[c]	P	NA	7	0	0	14	11
	Grand Rapids[c]	P	NA	9	0	0	0	13
	Bay City	P	6	6	[e]0	[e]0	20	14
	Charlevoix	P	11	10	[e]0(2)	[e]1	18(2)	15
	Detroit	P	6	7	[e]0	[e]0	17	8
	Grand Rapids	P	5	7	[e]0	[e]0	20	9
	Lansing	P	6	7	[e]0(2)	[e]0	18(2)	15
	Marquette	P	12	10	[e]0(2)	[e]0	32(2)	23
	Monroe	P	3	5	[e]0(2)	[e]0	0(2)	3
	South Haven	P	6	7	[e]0(5)	[e]0	15(5)	9
Minn:	Minneapolis[c]	P	NA	9	0	0	30	16
	Bemidji	P	8	8	0	0	22	21
	Duluth	P	21	17	0	0	43	28
	Fergus Falls	P	8	7	0	0	18	14
	Little Falls	P	20	16	0	0	53	27
	Mankato	P	5	6	0	0	19	11
	Minneapolis	P	12	12	0	0	22	24
	Rochester	P	NS	7	NS	0	NS	12
	Worthington	P	7	6	0	0	12	0

See footnotes at end of table.

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Table 2. Concentrations of radionuclides in milk for August 1971 and 12-month period, September 1970 through August 1971—continued

Sampling location		Type of sample[a]	Radionuclide concentration (pCi/liter)					
			Strontium-90		Iodine-131		Cesium-137	
			Monthly average[b]	12-month average	Monthly average[b]	12-month average	Monthly average[b]	12-month avarege
UNITED STATES—continued								
Miss:	Jackson[c]	P	NA	12	0	0	15	9
Mo:	Kansas City[c]	P	NA	7	0	0	19	5
	St. Louis[c]	P	NA	6	0	0	19	6
Mont:	Helena[c]	P	NA	6	0	0	12	12
Nebr:	Omaha[c]	P	NA	6	0	0	13	4
Nev:	Las Vegas[c]	P	NA	2	0	0	0	1
N.H:	Manchester[c]	P	NA	9	0	0	19	21
N.J:	Trenton[c]	P	NA	9	0	0	14	11
N. Mex:	Albuquerque[c]	P	NA	3	0	0	0	0
N.Y:	Buffalo[c]	P	7	7	0	0	15	11
	New York City[c]	P	NA	9	0	0	15	16
	Syracuse[c]	P	NA	7	0	0	20	10
	Albany	P	6	7	0	0	0	0
	Buffalo	P	0	0	0	0	0	0
	Massena	P	8	8	0	0	25	24
	New York City	P	0	8	0	0	0	0
	Syracuse	P	7	4	0	0	0	0
N.C:	Charlotte[c]	P	NA	11	0	0	11	13
N. Dak:	Minot[c]	P	NA	10	0	0	22	9
Ohio:	Cincinnati[c]	P	NA	7	0	0	0	2
	Cleveland[c]	P	NA	8	0	0	0	10
Okla:	Oklahoma City[c]	P	NA	6	0	0	0	8
Oreg:	Portland[c]	P	7	5	0	0	11	5
	Baker	P	NA	2	0	0	0	6
	Coos Bay	P	NA	6	0	0	0	9
	Eugene	P	NA	3	0	0	0	3
	Medford	P	NA	1	0	0	0	5
	Portland composite	P	NA	6	0	0	0(2)	5
	Portland local	P	NA	4	0	0	10(2)	10
	Redmond	P	NA	3	0	0	0	2
	Tillamook	R	NA	7	0	0	25	16
Pa:	Philadelphia[c]	P	NA	8	0	0	15	9
	Pittsburgh[c]	P	NA	11	0	0	11	13
	Dauphin	P	NA	7	0	1	16	13
	Erie	P	NA	6	0	0	20	19
	Philadelphia	P	NA	8	0	0	16	15
	Pittsburgh	P	NA	11	0	1	0	17
R.I:	Providence[c]	P	NA	8	0	0	17	19
S.C:	Charleston[c]	P	9	9	0	0	20	15
S. Dak:	Rapid City[c]	P	NA	6	0	0	14	5
Tenn:	Chattanooga[c]	P	NA	9	0	0	15	9
	Memphis[c]	P	NA	7	0	0	14	9
	Chattanooga	P	NA	9	0	0	15	15
	Clinton	R	NA	9	0(2)	0	5(2)	16
	Fayetteville	P	NA	10	0(2)	0	6(2)	13
	Kingston	R	NA	9	0(2)	0	15(2)	18
	Knoxville	P	NA	6	0(2)	0	17(2)	13
	Lawrenceburg	R	NA		0(2)	0	10(2)	10
	Nashville	P	NA	6	0	0	12	13
	Pulaski	R	NA	9	0(2)	0	12(2)	6
Tex:	Austin[c]	P	NA	1	0	0	0	0
	Dallas[c]	P	NA	6	0	0	0	5
	Amarillo	R	NS	4	NS	0	NS	2
	Corpus Christi	R	5	4	0	0	0	0
	El Paso	R	2	3	0	0	0	0
	Fort Worth	R	NS	4	NS	0	NS	0
	Harlingen	R	NS	2	NS	0	NS	0
	Houston	R	NS	7	NS	0	NS	16
	Lubbock	R	4	3	0	0	0	0
	Midland	R	NS	2	NS	0	NS	0
	San Antonio	R	NS	4	NS	0	NS	0
	Texarkana	R	NS		NS	0	NS	
	Tyler	R	9	14	0	0	18	17
	Uvalde	R	NS		NS	0	NS	
	Wichita Falls	R	8	6	0	0	0	4
Utah:	Salt Lake City[c]	P	6	5	0	0	25	16
Vt:	Burlington[c]	P	NA	6	0	0	11	14
Va:	Norfolk[c]	P	NA	9	0	0	0	6
Wash:	Seattle[c]	P	NA	5	0	0	0	4
	Spokane[c]	P	NA	6	0	0	11	4
	Benton County	R	NS	1	NS	0	NS	2
	Franklin County	R	4	4	0	0	0	5
	Sandpoint, Idaho	R	15	13	0	0	37	22
	Skagit County	R	NA	9	0(2)	0	15(2)	18
W. Va:	Charleston[c]	P	NA	8	0	0	0	9
Wisc:	Milwaukee[c]	P	NA	6	0	0	0	11
Wyo:	Laramie[c]	P	NA	5	0	0	0	1
CANADA:								
Alberta:	Calgary	P	NA		(d)		18	19
	Edmonton	P	NA		(d)		30	23
British Columbia:	Vancouver	P	NA		(d)		37	24
Manitoba:	Winnipeg	P	NA		(d)		28	24

See footnotes at end of table.

Table 2. Concentrations of radionuclides in milk for August 1971 and 12-month period, September 1970 through August 1971—continued

Sampling location		Type of sample[a]	Radionuclide concentration (pCi/liter)					
			Strontium-90		Iodine-131		Cesium-137	
			Monthly average[b]	12-month average	Monthly average[b]	12-month average	Monthly average[b]	12-month average
CANADA—continued								
New Brunswick:	Fredericton	P	NA		([d])		29	25
Newfoundland:	St. John's	P	NA		([d])		51	31
Nova Scotia:	Halifax	P	NA		([d])		48	24
Ontario:	Ottawa	P	NA		([d])		12	15
	Sault Ste. Marie	P	NA		([d])		44	33
	Thunder Bay	P	NA		([d])		18	26
	Toronto	P	NA		([d])		17	13
	Windsor	P	NA		([d])		10	11
Quebec:	Montreal	P	NA		([d])		14	18
	Quebec	P	NA		([d])		30	29
Saskatchewan:	Regina	P	NA		([d])		12	14
	Saskatoon	P	NA		([d])		18	18
CENTRAL AND SOUTH AMERICA:								
Colombia:	Bogota	P	0	1	0	0	0	0
Chile:	Santiago	P	0	0	0	0	12	2
Ecuador:	Guayaquil	P	0	0	0	0	0	0
Jamaica:	Mandeville	P	4	4	0	0	63	51
Venezuela:	Caracas	P	2	1	0	0	0	0
Canal Zone:	Cristobal[c]	P	NA	1	0	0	11	10
Puerto Rico:	San Juan[c]	P	NA	3	0	0	14	12
PMN network average[f]			8	7	0	0	11	9

[a] P, pasteurized milk.
R, raw milk.

[b] When an individual sampling result was equal to or less than the practical reporting level, a value of "0" was used for averaging. Monthly averages less than the practical reporting level reflect the fact that some but not all of the individual samples making up the average contained levels greater than the practical reporting level. When more than one analysis was made in a monthly period, the number of samples in the monthly average is given in parentheses.

[c] Pasteurized Milk Network station. All other sampling locations are part of the State or National network.

[d] Radionuclide analysis not routinely performed.

[e] The practical reporting levels for these networks differ from the general ones given in the text. Sampling results for the networks were equal to or less than the following practical reporting levels:

Iodine-131: Colorado—25 pCi/liter
Michigan—14 pCi/liter
Oregon—15 pCi/liter

Cesium-137: Colorado—25 pCi/liter
New York—20 pCi/liter
Oregon—15 pCi/liter

Strontium-90: New York—3 pCi/liter

[f] This entry gives the average radionuclide concentrations for the Pasteurized Milk Network stations denoted by footnote [c].

NA, no analysis.
NS, no sample collected.

for Colorado. This is reflected in the practical reporting level for the Colorado milk network.

Federal Radiation Council guidance applicable to milk surveillance

In order to place the U.S. data on radioactivity in milk presented in *Radiological Health Data and Reports* in perspective, a summary of the guidance provided by the Federal Radiation Council for specific environmental conditions was presented in the December 1970 issue of *Radiological Health Data and Reports.*

Data reporting format

Table 2 presents the integrated results of the international, national, and State networks discussed earlier. Column 1 lists all the stations which are routinely reported to *Radiological Health Data and Reports.* The relationship between the PMN stations and the State stations is shown in figure 2. The first column under each of the reported radionuclides gives the monthly average for the station and the number of samples analyzed in that month in parentheses. When an individual sampling result is equal to or below the practical reporting level for the radionuclide, a value of zero is used for averaging. Monthly averages are calculated using the above convention. Averages which are equal to or less than the practical reporting levels reflect the presence of radioactivity in some of the individual samples greater than the practical reporting level.

The second column under each of the radionuclides reported gives the 12-month average for the station as calculated from the preceding 12 monthly averages, giving each monthly average equal weight. Since the daily intake of radioactivity by exposed population groups,

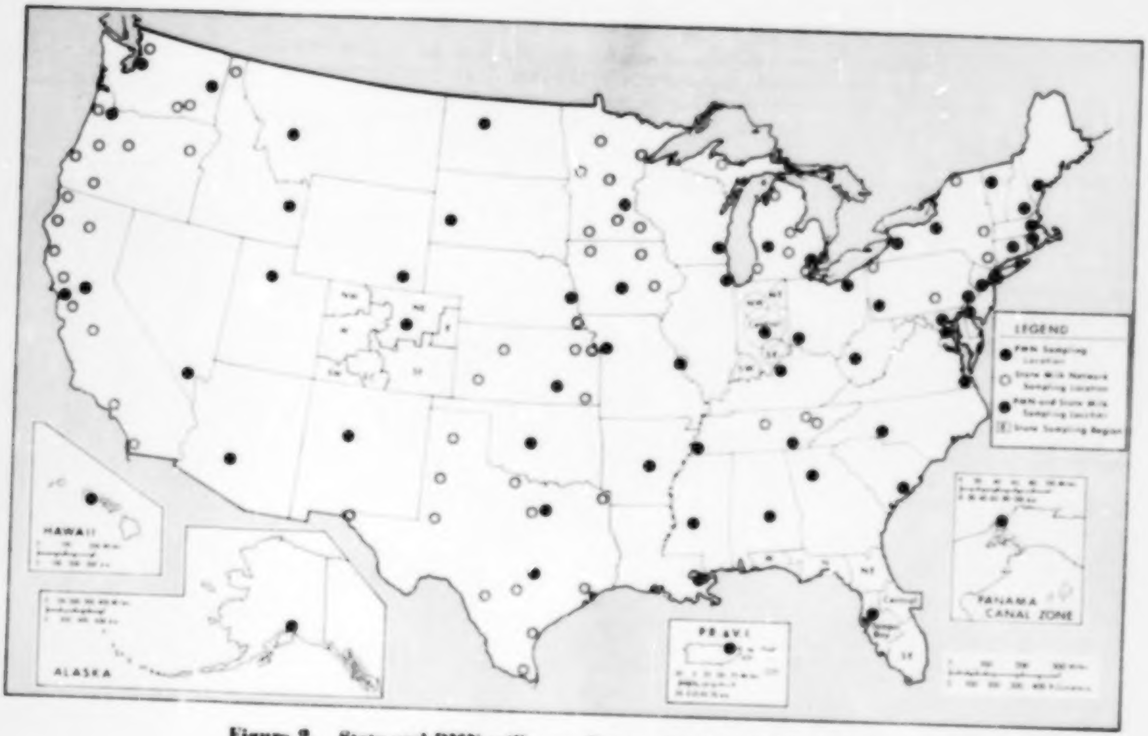

Figure 2. State and PMN milk sampling stations in the United States

averaged over a year, constitutes an appropriate criterion for the case where the FRC radiation protection guides apply, the 12-month average serves as a basis for comparison.

Discussion of current data

In table 2, surveillance results are given for strontium-90, iodine-131, and cesium-137 for August 1971 and the 12-month period, September 1970 to August 1971. Except where noted, the monthly average represents a single sample for the sampling station. Strontium-89 and barium-140 data have been omitted from table 2 since levels at the great majority of the stations for August 1971 were below the respective practical reporting levels. Table 3 gives monthly averages for those stations at which strontium-89 was detected.

Iodine-131 results are included in the table, even though they were generally below practical reporting levels. Because of the lower guide levels established by the Federal Radiation Council, levels in milk for this radionuclide are of particular public health interest.

Table 3. Strontium-89 in milk, August 1971

Sampling location		Radionuclide concentration (pCi/liter)
Calif:	Del Norte (State)	8
Kans:	Coffeyville (State)	7
	Kansas City (State)	8
N.Y:	New York City (State)	8
Chile:	Santiago (PAHO)	42
Ecuador:	Guayaquil (PAHO)	7
Jamaica:	Mandeville (PAHO)	7

In general, the practical reporting level for iodine-131 is numerically equal to the upper value of Range I (10 pCi/liter) of the FRC radiation protection guide.

Strontium-90 monthly averages ranged from 0 to 21 pCi/liter in the United States for August 1971, and the highest 12-month average

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was 17 pCi/liter (Duluth, Minn.) representing 8.5 percent of the Federal Radiation Council radiation protection guide. Cesium-137 monthly averages ranged from 0 to 53 pCi/liter in the United States for August 1971, and the highest 12-month average was 68 pCi/liter (Southeast Florida), representing 1.9 percent of the value derived from the recommendations given in the Federal Radiation Council report. Of particular interest are the consistently higher cesium-137 levels that have been observed in Florida (*8*) and Jamaica.

Acknowledgment

Appreciation is expressed to the personnel of the following agencies who provide data for their milk surveillance network:

Bureau of Radiological Health
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Canadian Department of National
Health and Welfare

Radiological Health Section
Division of Occupational and
Radiological Health
Colorado Department of Health

Radiological Health Services
Division of Medical Services
Connecticut State Department of Health

Radiological and Occupational
Health Section
Department of Health and
Rehabilitative Services
State of Florida

Bureau of Environmental Sanitation
Division of Sanitary Engineering
Indiana State Board of Health

Division of Radiological Health
Environmental Engineering Services
Iowa State Department of Health

Radiation Control Section
Environmental Health Division
Kansas State Department of Health

Radiological Health Services
Division of Occupational Health
Michigan Department of Health

Radiation Control Section
Division of Environmental Health
State of Minnesota Department of Health

Bureau of Radiological Pollution Control
New York State Department of
Environmental Conservation

Environmental Radiation Surveillance
Program
Division of Sanitation and Engineering
Oregon State Board of Health

Radiological Health Section
Bureau of Environmental Health
Pennsylvania Department of Public Health

Radiological Health Services
Division of Preventable Diseases
Tennessee Department of Public Health

Division of Occupational Health
Environmental Health Services
Texas State Department of Health

Radiation Control Section
Division of Health
Washington Department of
Social and Health Services

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(2) U.S. ATOMIC ENERGY COMMISSION, DIVISION OF ISOTOPES DEVELOPMENT. Chart of the Nuclides, Tenth Edition revised to December 1968. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (1970)

(3) NATIONAL CENTER FOR RADIOLOGICAL HEALTH. Section I. Milk Surveillance. Radiol Health Data Rep 9:730-746 (December 1968).

(4) ROSENSTEIN, M. and A. S. GOLDIN. Statistical technics for quality control of environmental radioassay. Health Lab Sci 2:93 (April 1965).

(5) KNOWLES, F. interlaboratory study of iodine-131, cesium-137, barium-140, strontium-89, and strontium-90 measurements in milk, May-July 1970, Technical experiment 70-M[illegible]AQ-1. Analytical Quality Control Service, Bureau of Radiological Health (September 1970).

(6) NEILL, R. H. and D. R. SNAVELY. State Health Department sampling criteria for surveillance of radioactivity in milk. Radiol Health Data Rep 8:621-627 (November 1967).

(7) ROBINSON, P. B. A comparison of results between the Public Health Service Raw Milk and Pasteurized Milk Networks for January 1964 through June 1966. Radiol Health Data Rep 9:475-488 (September 1968).

(8) PORTER, C. R., C. R. PHILLIPS, M. W. CARTER, and B. KAHN. The cause of relatively high cesium-137 concentrations in Tampa, Florida, milk. Radioecological Concentration Processes, Proceedings of an International Symposium held in Stockholm, April 25-29, 1966. Pergamon Press, New York, N.Y. (1966) pp. 95–101.

Food and Diet Surveillance

Efforts are being made by various Federal and State agencies to estimate the dietary intake of selected radionuclides on a continuing basis. These estimates, along with the guidance developed by the Federal Radiation Council, provide a basis for evaluating the significance of radioactivity in foods and diet.

Networks presently in operation and reported routinely include those listed below. These networks provide data useful for developing estimates of nationwide dietary intakes of radionuclides. Programs reported in *Radiological Health Data and Reports* are as follows:

Program	Period reported	Issue
California Diet Study	July–December 1970	November 1971
Carbon-14 and Tritium in Total Diet and Milk	January–June 1971	December 1971
Connecticut Standard Diet	January–December 1970	December 1970
Institutional Diet Samples	April–June 1971	November 1971
Strontium-90 in Tri-City Diets	January–December 1970	November 1971

Carbon-14 in Total Diet and Milk, January–June 1971

Environmental Protection Agency
Office of Radiation Programs

In July 1965, a program to determine the levels of carbon-14 and tritium in the total diet and milk in the United States was initiated. In December 1970, this program was transferred to the Office of Radiation Programs of the Environmental Protection Agency (EPA). Initially, monthly samples from each of the EPA Institutional Total Diet Sampling Network (ITDSN) and Pasteurized Milk Network (PMN) stations were composited and analyzed according to six arbitrarily selected regions: Northeast, South, Delta, Central, Southwest, and Northwest. Figure 1 shows the ITDSN and PMN sampling stations in each of the designated regions.

In January 1966, the program was modified to include selected stations in each of the previously mentioned regions plus Alaska and Hawaii. The nine geographically distributed sampling stations are: Palmer, Alaska; Honolulu, Hawaii; Idaho Falls, Idaho; Chicago, Ill; New Orleans, La; Boston, Mass; Portland, Oreg; and Charleston, S.C. Los Angeles, Calif. is not a PMN station, but a special milk sample is collected for purposes of comparison with the routine ITDSN sample.

A 1-liter milk sample and a 2-kilogram food sample are sent to the PHS Northeastern Radiological Health Laboratory for analysis. The milk and total diet samples analyzed represent the samples collected for that month.

The carbon-14 analyses are performed semiannually. The tritium analyses were discontinued in July 1969 because the results were only slightly above the limit of detectability and were less than 1 percent of the maximum permissible concentration for milk and food consumed by the general population.

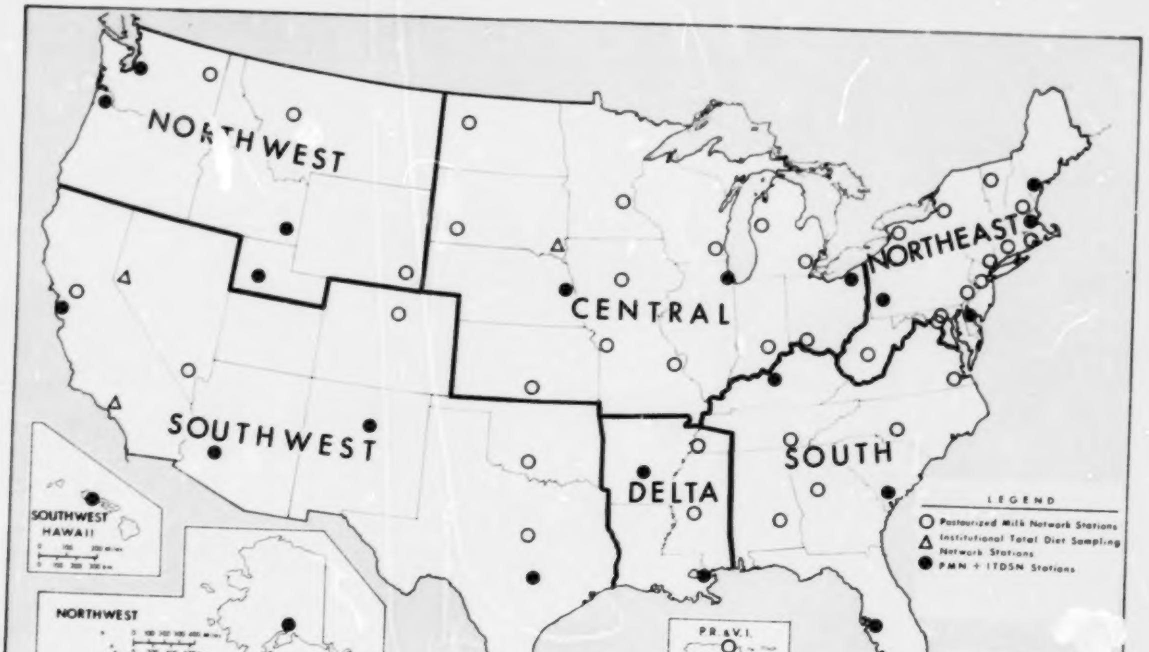
NORTHWEST
CENTRAL
NORTHEAST
SOUTHWEST
SOUTH
DELTA
SOUTHWEST HAWAII
NORTHWEST ALASKA
P.R. & V.I.
LEGEND
○ Pasteurized Milk Network Stations
△ Institutional Total Diet Sampling Network Stations
● PMN + ITDSN Stations
0 100 200 300
0 100 200 300 400 Kilometers

Figure 1. ITDSN and PMN sampling stations

Analytical procedures

The carbon-14 content is determined by combustion of the milk or food sample and collection and purification of the evolved carbon dioxide. The carbon dioxide is then converted to methane and counted in a gas-proportional counter (*1*).

Results and discussion

The carbon-14 concentration in food and milk was measured as dpm of carbon-14 per gram of carbon and converted to pCi/kg or pCi/liter by using the percent carbon in the sample. The carbon content in food ranged from 8.9 to 11.1 percent with an average of 10.4 percent, and the carbon content in milk ranged from 4.5 to 7.4 percent with an average of 5.4 percent. Table 1 shows the dpm per gram of carbon and the carbon-14 concentrations in total diet and milk for January–June 1971.

Other coverage in *Radiological Health Data and Reports:*

Period	Issue
July 1965–December 1968	November 1969
January 1969–June 1970	January 1971
July–December 1970	May 1971

REFERENCE

(*1*) DROBINSKI, J. C. JR., D. P. LAGATTA, A. S. GOLDIN, and J. G. TERRILL. Analyses of environmental samples for carbon-14 and tritium. Health Phys 11:385–395 (May 1965).

Table 1. Carbon-14 in total diet and milk, January–June 1971

Location		Date collected	Total diet		Milk	
			dpm/g C ± 2σ	pCi/kg ± 2σ	dpm/g C ± 2σ	pCi/liter ± 2σ
Alaska:	Palmer	April	18.02 ± 0.33	840 ± 30		
		May			15.39 ± 0.31	390 ± 10
Calif:	Los Angeles	April	16.97 ± .31	790 ± 30	17.36 ± .36	440 ± 10
Hawaii:	Honolulu	April	17.02 ± .28	790 ± 30	NS	NS
Idaho:	Idaho Falls	April	18.48 ± .36	860 ± 30	18.37 ± .46	460 ± 10
Ill:	Chicago	April			16.00 ± .30	400 ± 10
La:	New Orleans	April	17.08 ± .30	800 ± 30		
		May			17.88 ± .40	450 ± 10
Mass:	Boston	April	15.92 ± .38	740 ± 40	15.07 ± .30	380 ± 10
Oreg:	Portland	April	16.85 ± .31	790 ± 30		
		May			17.96 ± .30	450 ± 10
S.C:	Charleston	April	17.50 ± .36	820 ± 30	17.17 ± .44	430 ± 10
Average			17.23	800	16.90	430

NS, no sample.

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Estimated Daily Intake of Radionuclides in Connecticut Standard Diet January–December 1970

Connecticut State Department of Health

The Connecticut State Department of Health has been analyzing a standard diet on a monthly basis since March 1963. Analysis are made for strontium-89, strontium-90, and gamma-ray emitters.

The standard diet was selected to represent the food intake of an 18-year old boy for 1 day (table 1). The total weight of the complete blended diet, averaging 3 kilograms, included milk and dairy products. When raw fruit or vegetables were sampled, they were washed before blending.

Table 1. Foods included in standard diet

Bread, white—8 slices
Butter, ½ stick
Carrots, scraped—½ cup
Celery, washed and trimmed—3 stalks
Cookies—4
Cottage cheese—⅔ cup
Cupcakes—2
Egg—1
Green beans, washed—½ cup
Ham—85 grams
Hamburger—227 grams
Ice cream—½ pint
Lettuce, washed—4.5 leaves
Milk—3 cups
Oatmeal—uncooked—43 grams
Orange—1
Peanut butter—2½ tablespoons
Pears, canned—2 halves with juice
Potatoes, washed, not peeled—2
Sugar—5 tablespoons
Tomato juice—113 grams
Tuna fish, drained—43 grams

Cesium-137 concentrations were determined by gamma-ray spectrometry (*1*). Strontium-89 and strontium-90 concentrations were determined by chemical separation techniques (*1*).

Table 2 presents the analytical results for the Connecticut standard diet from January through December 1970. Results representative of the total daily intake for the radionuclides observed are presented in table 3.

Table 2. Radionuclide concentrations in Connecticut standard diet,[a] January-December 1970

Month (1970)	Potassium (g/kg)	Strontium-90 (pCi/kg)	Cesium-137 (pCi/kg)
January	2.2	5.8	10
February	2.0	5.3	5
March	1.9	6.3	5
April	1.9	5.4	10
May	2.2	8.1	10
June	2.0	5.7	20
July	1.9	8.4	10
August	2.5	8.0	20
September	2.2	8.2	10
October	NS	NS	NS
November	2.1	NA	10
December	2.2	8.3	13

[a] All strontium-89 values were below the detectable level for this period.
NA, no analysis.
NS, no sample.

In order to evaluate general trends, the strontium-90 and cesium-137 daily intakes are plotted as a function of time in figures 1 and 2.

Table 3. Daily radionuclide intakes in Connecticut standard diet,[a] January-December 1970

Month (1970)	Potassium (g/day)	Strontium-90 (pCi/day)	Cesium-137 (pCi/day)
January	7.1	18.6	40
February	6.8	17.7	20
March	5.8	19.3	20
April	6.4	18.0	40
May	6.8	25.6	30
June	7.6	19.6	60
July	5.9	25.6	30
August	8.7	28.2	70
September	7.5	28.1	50
October	NS	NS	NS
November	6.7	NA	40
December	7.3	27.0	40

[a] All strontium-89 values were below the detectable level limit for this period.
NA, no analysis.
NS, no sample.

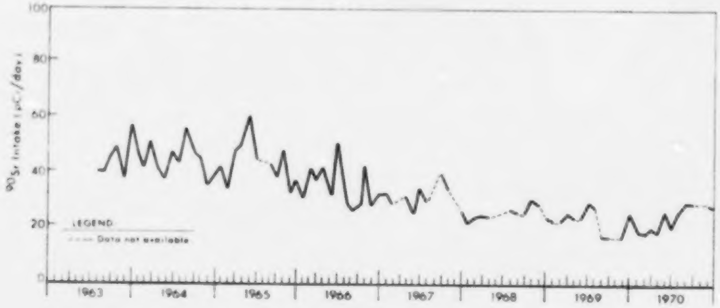

Figure 1. Strontium–90 intake in Connecticut standard diet 1963–December 1970

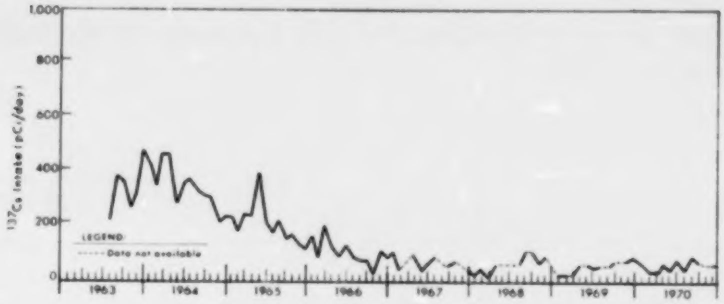

Figure 2. Cesium–137 intake in Connecticut standard diet 1963–December 1970

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
July–December 1969	December 1970

REFERENCE

(*1*) CONNECTICUT STATE DEPARTMENT OF HEALTH. Estimated daily intake of radionuclides in Connecticut standard diet, March 1963–December 1964. Radiol Health Data 6:381–382 (July 1965).

SECTION II. WATER

The Environmental Protection Agency and other Federal, State, and local agencies operate extensive water quality sampling and analysis programs for surface, ground, and treated water. Most of these programs include determinations of gross beta and gross alpha radioactivity and specific radionuclides.

Although the determination of the total radionuclide intake from all sources is of primary importance, a measure of the public health importance of radioactivity levels in water can be obtained by comparison of the observed values with the Public Health Service Drinking Water Standards (*1*). These standards, based on consideration of Federal Radiation Council (FRC) recommendations (*2-4*), set the limits for approval of a drinking water supply containing radium-226 and strontium-90 at 3 pCi/liter and 10 pCi/liter, respectively. Higher concentrations may be acceptable if the total intake of radioactivity from all sources remains within the guides recommended by FRC for control action. In the known absence [1] of strontium-90 and alpha-particle emitters, the limit is 1,000 pCi/liter gross beta radioactivity, except when additional analysis indicates that concentrations of radionuclides are not likely to cause exposures greater than the limits indicated by the Radiation Protection Guides. Surveillance data from a number of Federal and State programs are published periodically to show current and long-range trends. Water sampling activities reported in *Radiological Health Data and Reports* are listed below.

Water sampling program	Period reported	Issue
California	January–December 1969	October 1971
Gross Radioactivity in Surface Waters of the United States	March 1971	November 1971
Interstate Carrier Drinking Water	1970	July 1971
Kansas	January–June 1970	November 1971
Minnesota	January–June 1970	November 1971
North Carolina	January–December 1967	May 1969
New York	July 1969–June 1970	September 1971
Radiostrontium in Tap Water, *HASL*	January–June 1970	April 1971
Tritium in Community Water Supplies	1969	December 1970
Tritium Surveillance System	April–June 1971	November 1971
Washington	July 1968–June 1969	February 1971

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[1] Absence is taken to mean a negligibly small fraction of the specific limits of 3 pCi/liter and 10 pCi/liter for unidentified alpha-particle emitters and strontium-90, respectively.

REFERENCES

(*1*) U.S. PUBLIC HEALTH SERVICE. Drinking water standards, revised 1962, PHS Publication No. 956. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (March 1963).

(*2*) FEDERAL RADIATION COUNCIL. Radiation Protection Guidance for Federal Agencies. Memorandum for the President, September 1961. Reprint from the Federal Register of September 26, 1961.

(*3*) FEDERAL RADIATION COUNCIL. Background material for the development of Radiation Protection Standards, Report No. 1. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (May 1960).

(*4*) FEDERAL RADIATION COUNCIL. Background material for the development of Radiation Protection Standards, Report No. 2. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (September 1961).

Radioactivity in Kansas Surface Waters, January–December 1970

Radiation Control Section
Kansas State Department of Health

Monitoring the levels of radioactivity in the surface waters of Kansas is conducted by the Kansas State Department of Health, Radiation Control Section, in cooperation with the Radiological Laboratory and Water Data Analysis Section. This surveillance program is important because of both the present and future potential use of Kansas surface waters for domestic, recreational, and industrial purposes.

Liter samples are collected every month at each location shown in figure 1. These samples are analyzed for alpha and beta radioactivity. Radioactivity in these waters consists of the natural radioactivity picked up by flowing streams, radioactivity from sewage discharge into the streams, and some contribution by industrial waste. The final contributing factor to radioactivity content is fallout, particularly over large expanses of open water, such as reservoirs and lakes.

Analytical procedures

Radioactivity analyses are performed by the Kansas Radiological Health Laboratory. Measurements of gross alpha and gross alpha-plus-beta radioactivity in total solids are made with a windowless gas-flow proportional counter. Each sample is evaporated in an aluminum planchet, dried at 250° C. and then counted. Specific radionuclide analyses are determined by gamma spectroscopy or chemical separation.

Discussion

Table 1 shows the gross alpha and gross alpha-plus-beta radioactivity in the total solids in Kansas surface waters from January through December 1970. These waters are used for domestic, industrial, and recreational purposes. Recently there has been much discussion as to establishing a nuclear waste repository in Kansas. If the decision is made to establish such a repository, the entire environmental surveillance program including surface water will be increased around the proposed site.

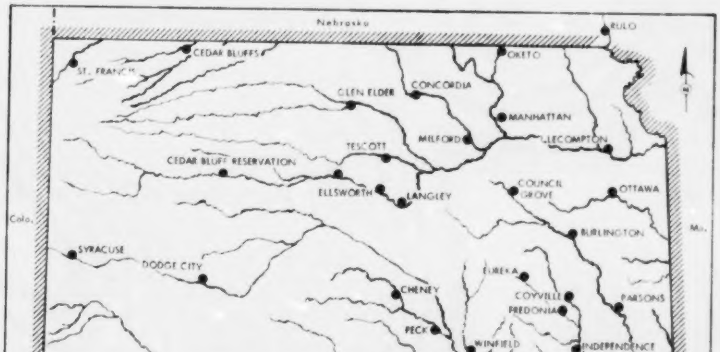
Nebraska
RULO
CEDAR BLUFFS
ST. FRANCIS
OKETO
CONCORDIA
GLEN ELDER
MANHATTAN
MILFORD
LECOMPTON
TESCOTT
CEDAR BLUFF RESERVATION
ELLSWORTH
LANGLEY
COUNCIL GROVE
OTTAWA
Colo.
Mo.
BURLINGTON
SYRACUSE
DODGE CITY
EUREKA
CHENEY
COYVILLE
FREDONIA
PARSONS
PECK
WINFIELD
INDEPENDENCE
ARKANSAS CITY
BAXTER SPRINGS
Oklahoma
FORGAN
● Water Sampling Station
0 25 50 75 Miles

Figure 1. Kansas surface water sampling stations

Table 1. Gross radioactivity in Kansas surface waters, January–June 1970

River	Sampling station	Radioactivity concentration (pCi/liter)											
		January		February		March		April		May		June	
		Alpha	Beta	Alpha	Beta	Alpha	Beta	Alpha	Beta	Alpha	Beta	Alpha	Beta
Arkansas:	Arkansas City	[a]16	14	ND	[a]31	[a]3	ND	[a]11	[a]21	[a]3	72	[a]6	[a]22
	Dodge City	[a]18	ND	[a]12	0	[a]15	ND	[a]1	86	[a]14	20	[a]16	[a]33
	Syracuse	36	ND	NS	NS	39	13	NS	NS	[a]4	71	35	14
Beaver Creek:	Cedar Bluffs	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	ND	33
Big Blue:	Manhattan	NS	NS	ND	[a]29	ND	[a]28	ND	[a]7	5	10	ND	[a]21
	Oketo	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Cimarron:	Forgan, Okla	[a]8	[a]3.3	NS	NS	NS	NS	[a]11	26	NS	NS	[a]2	ND
Fall:	Eureka	[a]3	[a]8	ND	ND	[a]2	[a]15	[a]4	[a]9	[a]3	76	ND	7
	Fredonia	ND	[a]16	[a]5	[a]27	ND	[a]16	2	26	[a]4	[a]32	ND	1
Kansas:	Lecompton	10	[a]22	[a]1	[a]9	NS	NS	[a]7	[a]40	[a]6	[a]22	[a]5	[a]32
Marais des Cygnes:	Ottawa	[a]2	ND	[a]2	[a]12	[a]5	ND	1	5	[a]3	[a]29	[a]2	[a]10
Missouri:	Rulo, Nebr	NS	NS	NS	NS	NS	NS	[a]3	4	[a]6	80	ND	ND
Neosho:	Burlington	ND	43	ND	[a]6	NS	NS	1	[a]29	NS	NS	NS	NS
	Council Grove	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	Parsons	ND	[a]19	[a]2	[a]16	[a]2	[a]23	2	[a]23	[a]2	[a]13	1	[a]20
Ninnescah:	Cheney	ND	[a]25	ND	[a]14	NS	NS	2	10	NS	NS	NS	NS
	Peck	NS	NS	NS	NS	NS	NS	[a]5	66	ND	2	1	[a]8
Republican:	Concordia	[a]3	29	[a]2	32	[a]1	[a]24	[a]4	37	1	[a]32	ND	[a]9
	Milford	[a]9	[a]25	[a]3	[a]23	NS	NS	[a]1	33	ND	8	8	37
	St. Francis	NS	NS	[a]7	[a]4	NS	NS	NS	NS	11	ND	NS	NS
Saline:	Tescott	[a]8	[a]35	[a]3	[a]4	[a]7	[a]30	[a]10	[a]61	[a]4	[a]64	[a]8	[a]16
	Wilson	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Smoky Hill:	Cedar Bluff	NS	NS	[a]12	[a]37	NS	NS	[a]6	43	[a]11	49	NS	NS
	Ellsworth	[a]3	[a]3	ND	21	[a]5	[a]29	[a]9	39	[a]8	68	4	28
	Langley	[a]2	[a]26	ND	[a]28	[a]5	[a]34	1	34	[a]3	33	[a]12	[a]18
Solomon:	Glenn Elder	[a]1	[a]20	[a]7	[a]33	[a]8	[a]16	1	51	[a]8	61	[a]3	37
Spring:	Baxter Springs	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Verdigris:	Coyville	[a]2	[a]33	[a]2	[a]14	ND	[a]23	[a]4	37	1.4	[a]26	NS	NS
	Independence	[a]4	[a]20	ND	[a]11	[a]4	[a]3	[a]4	50	ND	44	1	[a]10
Walnut:	Winfield	[a]1	[a]14	[a]7	ND	ND	[a]4	[a]2	30	2	[a]20	ND	[a]10

[a] When the counting rate of the sample is not equal to at least twice the 95-percent error, the value reported is not statistically significant but is the best available estimate.
ND, nondetectable.
NS, no sample.

Tabel 1. Gross radioactivity in Kansas surface waters, July–December 1970

River	Sampling station	Radioactivity concentration (pCi/liter)											
		July		August		September		October		November		December	
		Alpha	Beta	Alpha	Beta	Alpha	Beta	Alpha	Beta	Alpha	Beta	Alpha	Beta
Arkansas:	Arkansas City	[a]14	3	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	Dodge City	[a]16	9	27	ND	[a]11	ND	46	[a]11	NS	NS	[a]51	15
	Syracuse	NS	NS	[a]39	10	[a]21	[a]47	12	[a]48	[a]11	[a]12	65	ND
Beaver Creek:	Cedar Bluffs	NS	NS	[a]4	6	NS	NS	NS	NS	NS	NS	NS	NS
Big Blue:	Manhattan	1	[a]16	ND	5	[a]5	[a]17	[a]4	ND	[a]5	ND	NS	NS
	Oketo	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Cimarron:	Forgan, Okla	NS	NS	NS	NS	NS	NS	[a]19	ND	[a]7	ND	NS	NS
Fall:	Eureka	[a]4	[a]21	4	9	NS	NS	NS	NS	NS	NS	NS	NS
	Fredonia	ND	1	[a]4	2	ND	ND	ND	4	2	[a]19	ND	6
Kansas:	Lecompton	[a]8	ND	3	ND	ND	12	[a]2	[a]11	24	4	4	ND
Marais des Cygnes:	Ottawa	[a]6	7	1	[a]10	2	[a]12	2	ND	4	ND	2	2
Missouri:	Rulo, Nebr	1	ND	[a]4	ND	[a]7	[a]9	1	23	NS	NS	NS	NS
Neosho:	Burlington	NS	NS	NS	NS	NS	NS	[a]3	[a]8	NS	NS	[a]4	[a]10
	Council Grove	NS	NS	NS	NS	NS	NS	[a]4	[a]15	NS	NS	NS	NS
	Parson	NS	NS	[a]3	ND	[a]5	ND	2	6	[a]2	[a]18	[a]2	ND
Ninnescah:	Cheney	[a]7	27	[a]4	[a]14	ND	[a]9	[a]2	[a]4	3	1	1	ND
	Peck	ND	3	2	[a]11	NS	NS	2	4	ND	ND	ND	ND
Republican:	Concordia	[a]13	38	1	[a]16	[a]4	[a]13	[a]8	[a]3	[a]7	4	[a]8	[a]15
	Milford	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	St. Francis	NS	NS	NS	NS	NS	NS	14	[a]13	NS	NS	15	[a]17
Saline:	Tescott	3	[a]42	ND	[a]14	ND	[a]17	[a]9	[a]13	1	[a]13	[a]9	[a]13
	Wilson	NS	NS	NS	NS	NS	NS	[a]6	[a]25	NS	NS	NS	NS
Smoky Hill:	Cedar Bluff	NS	NS	[a]17	26	[a]7	44	NS	NS	NS	NS	[a]13	42
	Ellsworth	15	66	ND	3	7	ND	4	ND	6	ND	[a]7	ND
	Langley	NS	NS	[a]8	[a]12	2	ND	[a]11	[a]20	ND	[a]8	NS	NS
Solomon:	Glenn Elder	[a]6	24	1	27	[a]6	[a]19	[a]5	28	[a]4	39	8	19
Spring:	Baxter Springs	NS	NS	1	ND	[a]2	ND	[a]2	6	2	1	NS	NS
Verdigris:	Coyville	ND	[a]16	1	21	[a]4	ND	ND	25	1	9	2	14
	Independence	ND	6	2	ND	1	3	ND	[a]16	1	ND	[a]5	[a]6
Walnut:	Winfield	NS	NS	ND	6	2	ND	ND	17	23	1	NS	NS

[a] When the counting rate of the sample is not equal to at least twice the 95-percent error, the value reported is not statistically significant but is the best available estimate.
ND, nondetectable.
NS, no sample.

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SECTION III. AIR AND DEPOSITION

Radioactivity in Airborne Particulates and Precipitation

Continuous surveillance of radioactivity in air and precipitation provides one of the earliest indications of changes in environmental fission product radioactivity. To date, this surveillance has been confined chiefly to gross beta radioanalysis. Although such data are insufficient to assess total human radiation exposure from fallout, they can be used to determine when to modify monitoring in other phases of the environment.

Surveillance data from a number of programs are published monthly and summarized periodically to show current and long-range trends of atmospheric radioactivity in the Western Hemisphere. These include data from activities of the Environmental Protection Agency, the Canadian Department of National Health and Welfare, the Mexican Commission of Nuclear Energy, and the Pan American Health Organization.

In addition to those programs presented in this issue, the following programs were previously covered in *Radiological Health Data and Reports:*

Network	Period	Issue
Fallout in the United States and Other Areas, *HASL*	July–December 1968 and January–December 1969	January 1971
Plutonium in Airborne Particulates	January–March 1971	November 1971
Surface Air Sampling Program 80th Meridian Network, HASL	January–December 1968	April 1971
Mexican Air Monitoring Program	August–December 1970 and January 1971	October 1971

1. Radiation Alert Network
August 1971

Division of Atmospheric Surveillance
Environmental Protection Agency

Surveillance of atmospheric radioactivity in the United States is conducted by the Radiation Alert Network (RAN) which regularly gathers samples at 70 locations distributed throughout the country (figure 1). Most of these stations are operated by State Health Department personnel.

The station operators perform "field estimates" on the airborne particulate samples at 5 hours after collection, when most of the radon daughter products have decayed, and at 29 hours after collection, when most of the thoron daughter products have decayed. They also perform field estimates on dried precipitation samples and report all results to appropriate Environmental Protection Agency officials by mail or telephone depending on levels found. A compilation of the daily field estimates is available upon request from the Air Quality Information Systems Branch, Division of Atmospheric Surveillance, EPA, Research Triangle Park, North Carolina 27711. A detailed description of the sampling and analytical procedures was presented in the March 1968 issue of *Radiological Health Data and Reports.*

Table 1 presents the monthly average gross beta radioactivity in surface air particulates and deposition by precipitation, as measured by the field estimate technique, during August 1971.

All field estimates reported were within normal limits for the reporting station.

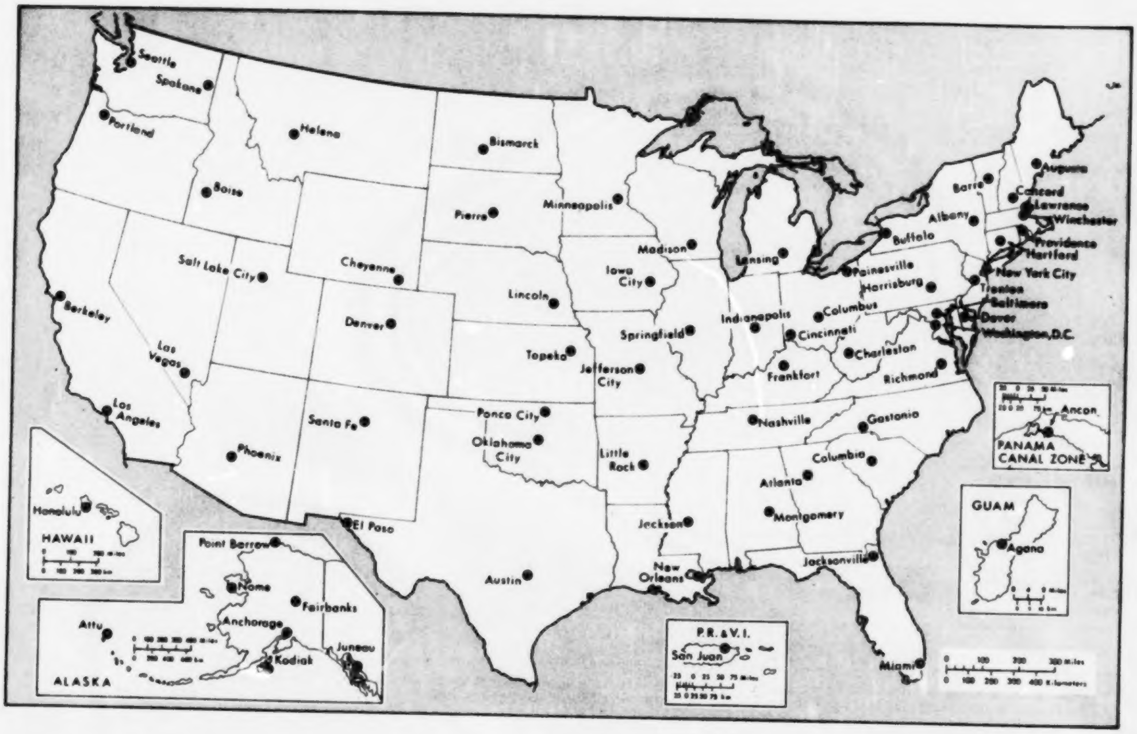
Seattle
Spokane
Portland
Helena
Bismarck
Boise
Minneapolis
Pierre
Cheyenne
Salt Lake City
Madison
Lansing
Painesville
Buffalo
Albany
Barre
Augusta
Concord
Lawrence
Winchester
Providence
Hartford
New York City
Harrisburg
Trenton
Baltimore
Dover
Washington, D.C.
Iowa City
Lincoln
Denver
Berkeley
Indianapolis
Columbus
Springfield
Cincinnati
Charleston
Topeka
Jefferson City
Frankfort
Richmond
Las Vegas
Los Angeles
Santa Fe
Ponca City
Oklahoma City
Nashville
Gastonia
Phoenix
Little Rock
Columbia
Atlanta
Montgomery
Jackson
El Paso
Austin
New Orleans
Jacksonville
Miami
Honolulu
HAWAII
Point Barrow
Nome
Fairbanks
Anchorage
Attu
Juneau
Kodiak
ALASKA
P.R. & V.I.
San Juan
GUAM
Agana
Ancon
PANAMA CANAL ZONE

Figure 1. Radiation Alert Network sampling stations

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Table 1. Gross beta radioactivity in surface air and precipitation, August 1971

Station location		Number of samples	Gross beta radioactivity (5-hour field estimate) (pCi/m³)			Number of samples	Total depth (mm)	Precipitation		
								Field estimation of deposition		
			Maximum	Minimum	Average[a]			Number of samples	Depth (mm)	Total deposition (mCi/m²)
Ala:	Montgomery	19	4	0	1	4	171	4	171	28
Alaska:	Anchorage	1	0	0	0	0				
	Attu Island	31	1	0	0	0				
	Fairbanks	18	1	0	0	7	58	7	58	16
	Juneau	0				0				
	Kodiak	0				0				
	Nome	0				0				
	Point Barrow	0				0				
Ariz:	Phoenix	13	4	1	2	0				
Ark:	Little Rock	11	2	0	0	0				
Calif:	Berkeley	17	1	0	0	0				
	Los Angeles	16	2	0	1	0				
C.Z:	Ancon	14	0	0	0	0				
Colo:	Denver	17	6	1	2	2	17	(b)		
Conn:	Hartford	17	1	0	0	7	67	7	67	0
Del:	Dover	19	1	0	1	0				
D.C:	Washington	21	1	0	0	0				
Fla:	Jacksonville	17	1	0	0	6	98	5	59	9
	Miami	17	0	0	0	9	144	9	144	0
Ga:	Atlanta	22	2	1	1	0				
Guam:	Agana	0				0				
Hawaii:	Honolulu	16	1	0	0	0				
Idaho:	Boise	17	4	0	2	0				
Ill:	Springfield	1	2	2	2	0				
Ind:	Indianapolis	15	2	0	1	0				
Iowa:	Iowa City	15	4	1	2	3	12	3	12	0
Kans:	Topeka	18	6	1	3	1	2	1	2	0
Ky:	Frankfort	0				0				
La:	New Orleans	14	1	0	0	10	141	(b)		
Maine:	Augusta	16	2	0	1	6	100	6	100	0
Md:	Baltimore	19	3	0	1	6	60	6	60	0
Mass:	Lawrence	17	2	0	1	4	115	4	115	0
	Winchester	18	3	0	1	4	87	4	87	0
Mich:	Lansing	18	3	0	1	8	28	8	28	4
Minn:	Minneapolis	18	3	0	1	3	29	3	29	5
Miss:	Jackson	13	7	0	2	1	22	1	22	2
Mo:	Jefferson City	18	7	1	2	0				
Mont:	Helena	18	5	1	2	3	22	3	22	0
Nebr:	Lincoln	18	10	0	5	3	16	3	16	3
Nev:	Las Vegas	16	3	1	1	0				
N.H:	Concord	0				0				
N.J:	Trenton	19	3	0	1	6	285	6	285	2
N. Mex:	Santa Fe	14	3	0	1	1	2	1	2	0
N.Y:	Albany	15	2	0	1	0				
	Buffalo	15	4	0	1	0				
	New York City	0				0				
N.C:	Gastonia	11	16	1	4	3	22	(b)		
N. Dak:	Bismarck	18	3	1	2	0				
Ohio:	Cincinnati	0				0				
	Columbus	3	1	1	1	0				
	Painesville	15	4	1	2	5	31	5	31	5
Okla:	Oklahoma City	0				0				
	Ponca City	16	5	0	2	4	92	4	92	0
Oreg:	Portland	14	1	0	0	2	7	2	7	1
Pa:	Harrisburg	18	3	0	1	0				
P.R:	San Juan	0				0				
R.I:	Providence	12	3	0	1	5	80	5	80	0
S.C:	Columbia	11	1	0	1	4	110	4	110	0
S. Dak:	Pierre	16	7	1	2	0				
Tenn:	Nashville	14	2	0	1	5	79	5	79	0
Tex:	Austin	1	1	1	1	1	47	(b)		
	El Paso	11	4	0	1	0				
Utah:	Salt Lake City	25	3	0	1	3	4	3	4	1
Vt:	Barre	16	5	1	2	5	103	5	103	13
Va:	Richmond	19	2	0	1	4	63	4	63	15
Wash:	Seattle	8	0	0	0	1	8	(b)		
	Spokane	14	2	0	1	0				
W. Va:	Charleston	18	3	0	1	6	56	6	56	4
Wisc:	Madison	17	2	0	1	4	80	4	80	9
Wyo:	Cheyenne	19	10	1	4	2	12	2	12	3
Network summary		914	16	0	1	148	76	4	67	4

[a] The monthly average is calculated by weighting the field estimates of individual air samples with length of sampling period.
[b] This station is part of the tritium surveillance system. No gross beta measurements are done.

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2. Canadian Air and Precipitation Monitoring Program,[1] August 1971

Radiation Protection Division
Department of National Health and Welfare

The Radiation Protection Division of the Canadian Department of National Health and Welfare monitors surface air and precipitation in connection with its Radioactive Fallout Study Program. Twenty-four collection stations are located at airports (figure 3), where the sampling equipment is operated by personnel from the Meteorological Services Branch of the Department of Transport. Detailed discussions of the sampling procedures, methods of analysis, and interpretation of results of the radioactive fallout program are contained in reports of the Department of National Health and Welfare (*1-5*).

A summary of the sampling procedures and methods of analysis was presented in the May 1969 issue of *Radiological Health Data and Reports.*

Surface air and precipitation data for August 1971 are presented in table 2.

Table 2. Canadian gross beta radioactivity in surface air and precipitation, August 1971

Station	Number of samples	Air surveillance, gross beta radioactivity (pCi/m³)			Precipitation measurements	
		Maximum	Minimum	Average	Average concentration (pCi/liter)	Total deposition (nCi/m²)
Calgary	51	0.3	0.2	0.2	NA	NA
Coral Harbour	5	.5	.1	.1	189	4.5
Edmonton	5	.3	.1	.2	102	1.2
Ft. Churchill	5	.2	.1	.1	119	4.4
Fredericton	5	.3	.1	.2	82	5.1
Goose Bay	5	.1	.1	.1	57	8.0
Halifax	5	.2	.1	.1	17	5.4
Inuvik	5	.1	.1	.1	103	4.8
Montreal	5	.2	.1	.1	42	4.3
Moosonee	5	.2	.1	.1	144	8.2
Ottawa	5	.3	.2	.2	42	5.2
Quebec	5	.3	.1	.2	41	8.7
Regina	5	.4	.1	.2	219	1.9
Resolute	5	.2	.1	.1	34	1.8
St. John's, Nfld.	5	.3	.1	.1	17	2.5
Saskatoon	5	.3	.1	.2	85	1.4
Sault Ste. Marie	5	.2	.1	.2	110	9.2
Thunder Bay	5	.2	.1	.1	130	5.2
Toronto	5	.3	.1	.2	85	7.7
Vancouver	5	.2	.1	.1	124	3.8
Whitehorse	5	.3	.1	.1	NA	NA
Windsor	5	.3	.1	.2	45	4.0
Winnipeg	5	.2	.1	.1	57	1.0
Yellowknife	5	.1	.0	.1	82	5.0
Network summary	146	0.5	0.0	0.1	87	4.7

NA, no analysis.

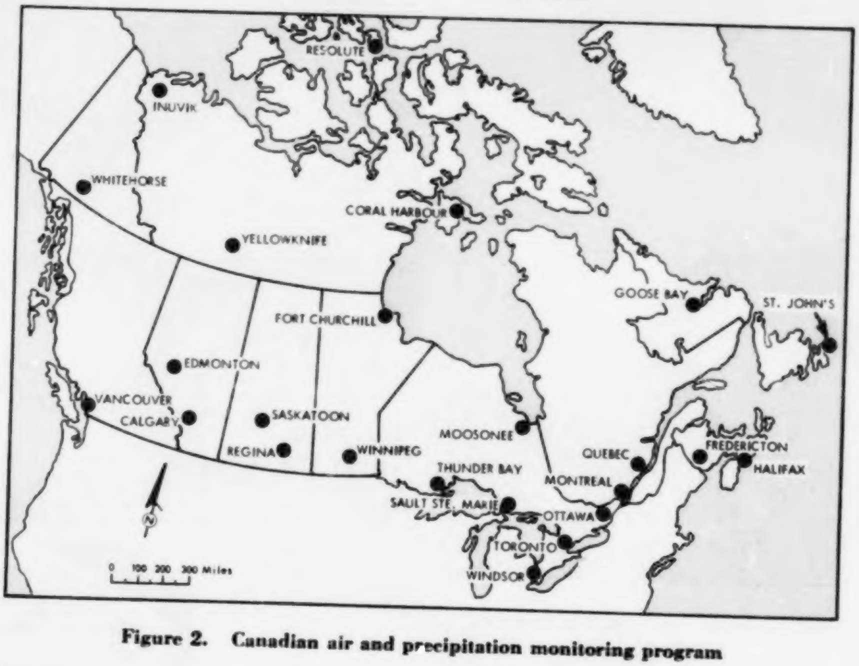
RESOLUTE
INUVIK
WHITEHORSE
CORAL HARBOUR
YELLOWKNIFE
GOOSE BAY
ST. JOHN'S
FORT CHURCHILL
EDMONTON
VANCOUVER
CALGARY
SASKATOON
MOOSONEE
REGINA
WINNIPEG
QUEBEC
FREDERICTON
HALIFAX
THUNDER BAY
MONTREAL
SAULT STE. MARIE
OTTAWA
TORONTO
WINDSOR
0 100 200 300 Miles

Figure 2. Canadian air and precipitation monitoring program

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[1] Prepared from information and data obtained from the Canadian Department of National Health and Welfare, Ottawa, Canada.

3. Pan American Air Sampling Program August 1971

Pan American Health Organization and Environmental Protection Agency

Gross beta radioactivity in air is monitored by countries in the Americas under the auspices of the collaborative program developed by the Pan American Health Organization (PAHO) and the Environmental Protection Agency (EPA) to assist PAHO-member countries in developing radiological health programs.

The air sampling station locations are shown in figure 3. Analytical techniques were described in the March 1968 issue of *Radiological Health Data and Reports*. The August 1971 air monitoring results from the participating countries are given in table 3.

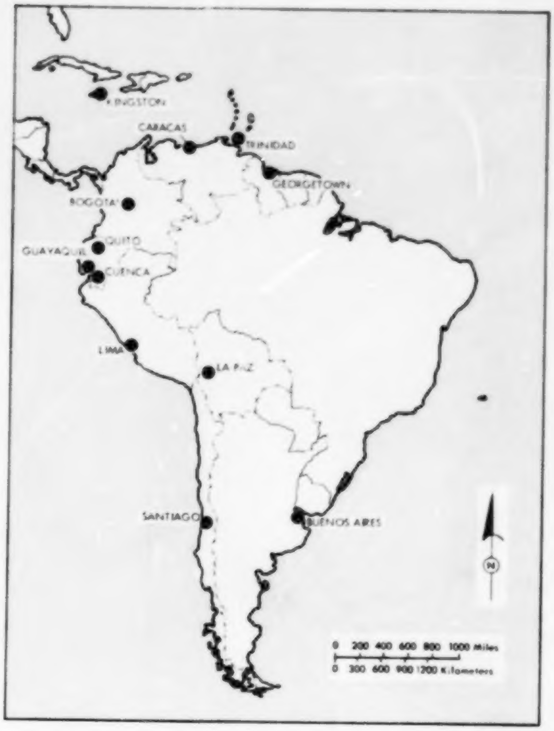

Figure 3. Pan American Air Sampling Program stations

Table 3. Summary of gross beta radioactivity in Pan American surface air, August 1971

Station location		Number of samples	Gross beta radioactivity (pCi/m³)		
			Maximum	Minimum	Average[a]
Argentina:	Buenos Aires	0			
Bolivia:	La Paz	9	3.02	0.13	0.74
Chile:	Santiago	30	1.95	.09	.69
Colombia:	Bogota	18	.49	.00	.09
Ecuador:	Cuenca	10	1.69	.04	.47
	Guayaquil	17	1.76	.11	.52
	Quito	15	2.39	.01	.41
Guyana:	Georgetown	5	.13	.02	.07
Jamaica:	Kingston	0			
Peru:	Lima	23	1.96	.05	.58
Venezuela:	Caracas	18	.27	.04	.17
West Indies:	Trinidad	6	.56	.06	.36
Pan American summary		151	3.02	0.01	0.45

[a] The monthly average is calculated by weighting the individual samples with length of sampling period. Values less than 0.005 pCi/m³ are reported and used in averaging as 0.00 pCi/m³.

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(*1*) BIRD, P. M., A. H. BOOTH, and P. G. MAR. Annual report of 1959 on the Radioactive Fallout Study Program, CNHW-RP-3. Department of National Health and Welfare, Ottawa, Canada (May 1960).

(*2*) BIRD, P. M., A. H. BOOTH, and P. G. MAR. Annual report for 1960 on the Radioactive Fallout Study Program, CNHW-RP-4. Department of National Health and Welfare, Ottawa, Canada (December 1961).

(*3*) MAR, P. G. Annual report for 1961 on the Radioactive Fallout Study Program, CNHW-RP-5. Department of National Health and Welfare, Ottawa, Canada (December 1962).

(*4*) BEALE, J. and J. GORDON. The operation of the Radiation Protection Division Air Monitoring Program, RPD-11. Department of National Health and Welfare, Ottawa, Canada (July 1962).

(*5*) BOOTH, A. H. The calculation of permissible levels of fallout in air and water and their use in assessing the significance of 1961 levels in Canada, RPD-21. Department of National Health and Welfare, Ottawa, Canada (August 1962).

Fallout in the United States and Other Areas,[1] January–December 1970

Health and Safety Laboratory
Atomic Energy Commission

Monthly fallout deposition rates for strontium-90 are determined by the Health and Safety Laboratory (HASL) for 35 sites in the United States and 90 locations in other countries. HASL data from all the active United States stations and other selected points in the Western Hemisphere (figure 1) covering the period from January–December 1970 are summarized in tables 1 through 4. All the stations of the 80th Meridian Network are represented.

Methods of collection

Two methods of fallout collection are employed by HASL. In the first, precipitation and dry fallout are collected for a period of 1 month in a stainless steel pot with an exposed area of 0.076 m². At the end of the collection period, the contents are transferred, by careful scrubbing with a rubber spatula, to a polyethylene sample bottle which is then shipped to the laboratory for analysis.

The second method involves the use of a polyethylene funnel, with an exposed area of 0.072 m², attached to an ion exchange column. After a 1-month collection, the inside of the funnel is wiped with a tissue, and the tissue is inserted in the end of the column, which is then sealed and sent to HASL for analysis. It has been shown that at the 95-percent confidence level there was no significant difference in the strontium-90 measurements obtained from samples collected by the two methods (*1*).

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[1] The data in this article were taken from "Fallout Program Quarterly Summary Report," HASL-243:A-1 to A-289 (July 1, 1971).

Table 1. Strontium-90 fallout in the United States, HASL, January–June 1970

Sampling location		Type of collection	Deposition (nCi/m²)					
			Jan	Feb	Mar	Apr	May	June
Ala:	Birmingham	pot	0.04	0.09	0.17	0.22	0.10	0.12
Alaska:	Anchorage	column	0.1	.01	(a)	.01	(b)	.16
	Barrow	column	(b)	(a)	(a)	(b)	(b)	(b)
	Cold Bay	column	.01	.04	.05	.07	.08	.18
	Fairbanks	column	(a)	.01	.01	(a)	.10	.16
	Juneau	column	.02	.01	.12	.11	.17	.17
	Nome	column	(a)	.01	(a)	(a)	.01	(b)
Calif:	W. Los Angeles	pot	.01	.03	.03	.01	(a)	.01
	San Francisco	column	.02	.03	.02	.01	.01	.02
Colo:	Denver	column	(a)	.02	.01	.02	.20	.20
Fla:	Coral Gables	pot	.05	.04	.04	.01	.46	.26
	Miami	column	.03	.01	.05	.03	.31	.17
Hawaii:	Honolulu	pot	.02	.02	.04	.24	.12	c.13
	Lihue	column	.04	(a)	.04	.06	(b)	.17
	Mauna Loa	column	(a)	.01	(a)	.11	.04	(a)
Ill:	Argonne	pot	.02	.04	.06	.24	.13	.38
La:	New Orleans	column	.04	.02	.13	.01	.17	.13
Minn:	International Falls	column	(b)	.01	.02	.08	.33	.08
Mo:	Columbia	column	.01	.02	.10	.17	.74	.34
Mont:	Helena	column	.01	(a)	.03	.03	.19	.24
N.Y:	New York City	pot	.01	.10	.18	.13	.24	.25
N. Dak:	Williston	column	.02	(a)	.01	.09	.25	.24
Ohio:	Wooster	pot	.01	.01	.03	.10	.30	.52
Okla:	Tulsa	pot	.02	.14	.22	.18	.29	.24
Oreg:	Medford	column	.06	.03	.03	.17	.02	.13
S.C:	Columbia	column	.04	.02	.15	.05	c.20	c.21
S. Dak:	Vermillion	pot	.01	.02	.17	.25	.28	.47
Tex:	Dallas	column	(a)	.06	.16	.19	.18	.06
	El Paso	column	(a)	.02	.03	.01	.10	.04
	Houston	column	.04	.04	.22	.12	.43	.04
Utah:	Salt Lake City	pot	.05	.09	.19	.12	.25	.44
Va:	Sterling	column	.01	.05	.16	.19	.17	.21
Wash:	Forks	column	.09	(a)	.17	.46	.10	.10
Wisc:	Green Bay	column	.02	(a)	.03	.08	.42	.13

[a] Zero or trace.
[b] Data not available.
[c] Proportioned from originally consolidated data.

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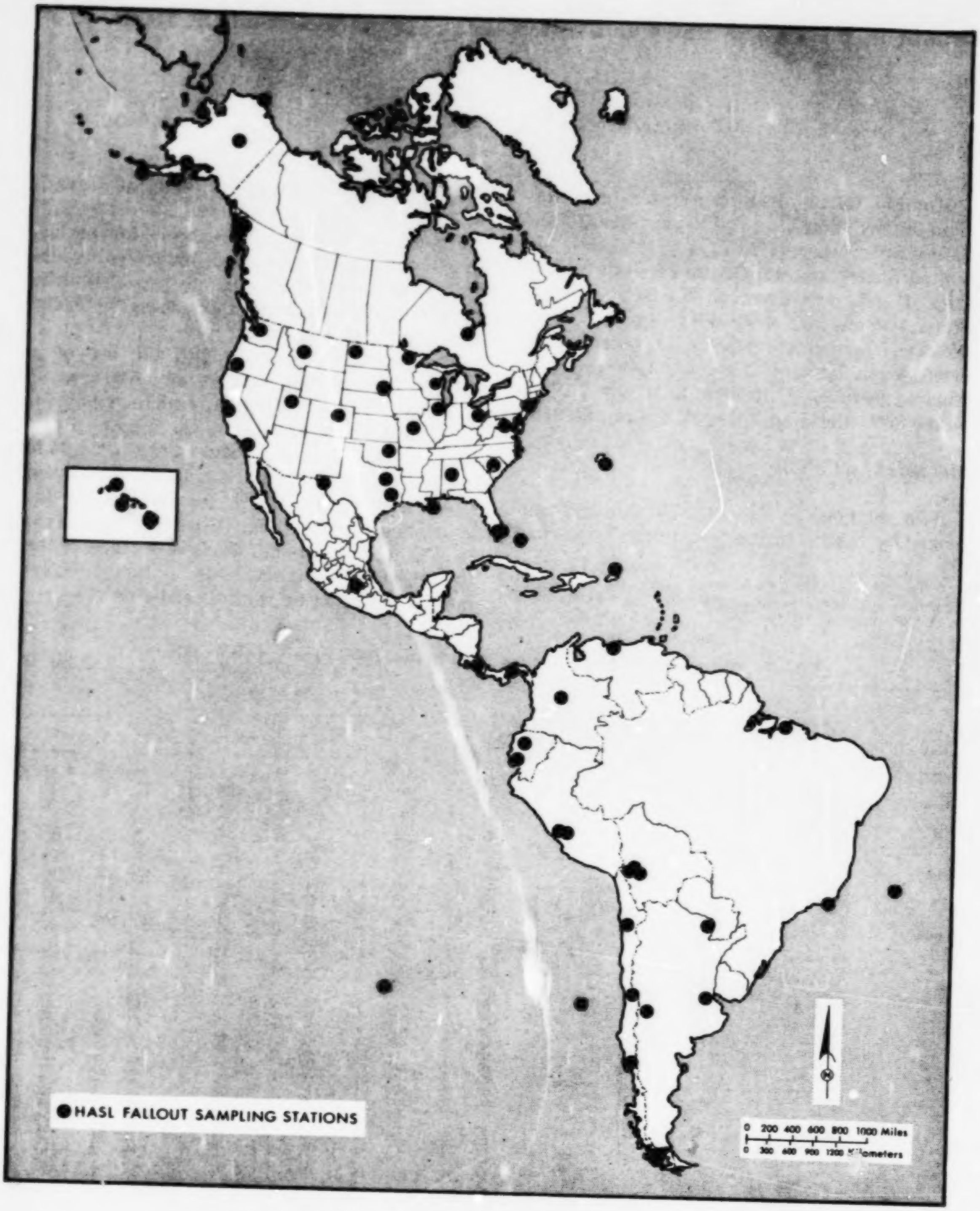
● HASL FALLOUT SAMPLING STATIONS
0 200 400 600 800 1000 Miles
0 300 600 900 1200 Kilometers

Figure 1. HASL fallout sampling stations in the Western Hemisphere

Table 2. Strontium-90 fallout in the United States, HASL, July–December 1970

Sampling location		Type of collection	Deposition (nCi/m²)					
			July	Aug	Sept	Oct	Nov	Dec
Ala:	Birmingham	pot	0.12	0.13	0.01	0.08	0.08	0.08
Alaska:	Anchorage	column	.18	.06	.06	.02	.01	.02
	Barrow	column	(b)	(b)	(b)	(b)	(b)	(b)
	Cold Bay	column	.14	.08	.08	.06	.04	.05
	Fairbanks	column	.11	(b)	.09	.04	.01	(b)
	Juneau	column	.28	.34	.18	.10	.02	(b)
	Nome	column	.16	(b)	.07	(b)	(b)	(b)
Calif:	W. Los Angeles	pot	.01	(a)	(a)	.01	.05	.07
	San Francisco	column	.01	(a)	(a)	.02	.04	.06
Colo:	Denver	column	.14	.05	.09	.03	.02	(a)
Fla:	Coral Gables	pot	[c].05	[c].05	.06	.06	.01	(b)
	Miami	column	.13	.04	.06	.04	(a)	.01
Hawaii:	Honolulu	pot	[c].13	[c].14	.12	.07	.01	.09
	Lihue	column	(a)	(a)	.04	.03	.03	.03
	Mauna Loa	column	.01	.01	(a)	(a)	(a)	.02
Ill:	Argonne	pot	.18	.44	.06	.06	.04	.03
La:	New Orleans	column	.16	.06	.04	.04	(a)	.04
Minn:	International Falls	column	.14	.31	.06	.06	.02	.02
Mo:	Columbia	column	.10	.16	.07	.07	.04	.06
Mont:	Helena	column	.27	.07	.04	.03	.01	.01
N.Y:	New York City	pot	.13	.12	.06	.09	.12	.05
N. Dak:	Williston	column	.43	.08	.10	.02	(a)	.01
Ohio:	Wooster	pot	.41	.08	.06	.04	.03	.06
Okla:	Tulsa	pot	.08	.09	.12	.10	.01	.05
Oreg:	Medford	column	(a)	.02	.01	.01	.04	.04
S.C:	Columbia	column	.13	.08	.04	.10	.03	(b)
S. Dak:	Vermillion	pot	.29	.07	.10	.08	.05	.03
Tex:	Dallas	column	.05	.11	.02	.38	(a)	.02
	El Paso	column	.06	.01	(a)	.01	(a)	.02
	Houston	column	(b)	.09	.04	.04	.02	(b)
Utah:	Salt Lake City	pot	.15	.06	.12	.05	.07	.10
Va:	Sterling	column	.21	.06	.01	.07	.04	.04
Wash:	Forks	column	.12	.05	.08	.12	.18	.12
Wisc:	Green Bay	column	.22	.14	.07	.06	.04	.01

[a] Zero or trace.
[b] Data not available.
[c] Proportioned from originally consolidated data.

Table 3. Strontium-90 fallout in North and South America, HASL, January–June 1970

Sampling location		Type of collection	Deposition (nCi/m²)					
			Jan	Feb	Mar	Apr	May	June
Argentina:	Buenos Aires	column	0.03	0.10	0.03	0.05	0.05	0.06
	Formosa	column	.10	(a)	.04	.02	.02	.09
	Malargue	column	.02	.07	.03	(a)	(a)	(a)
Bahamas:	Bimini	column	.02	.01	.09	.01	.07	.24
Bermuda:	Kindley AFB	column	(b)	(b)	(b)	(b)	(b)	(b)
Bolivia:	Chacaltaya	column	.02	.01	.01	.01	(a)	(a)
	La Paz (city)	column	.02	.01	.01	(a)	(a)	(a)
	La Paz (Ovejuyo)	column	(a)	(b)	(b)	(b)	(b)	(b)
Brazil:	Belem	column	(b)	(b)	(b)	(a)	(b)	(b)
	Rio de Janeiro	column	.08	.01	.01	.03	.04	.09
	Trindade Island	column	.01	.03	.02	.04	.04	.04
Canada:	Moosonee	column	(a)	(a)	.01	.09	.17	.30
Chile:	Antofagasta	column	(b)	(b)	(b)	(b)	(b)	(b)
	Conception	column	(b)	(a)	.01	.01	.04	.11
	Easter Island	column	.05	.05	.03	.04	(b)	.03
	Puerto Montt	column	(b)	(b)	(b)	(b)	(b)	.11
	Punta Arenas	column	(a)	.02	.01	.02	.02	(b)
	Santiago	pot	(a)	(a)	(b)	(a)	.01	.02
	Santiago	column	.01	(b)	(a)	(a)	.01	.03
Colombia:	Bogota	pot	(b)	(b)	(b)	.01	(a)	(a)
Costa Rica:	Turrialba	column	.02	.02	.04	.17	.07	.04
Equador:	Guayaquil	column	.02	(b)	.01	.01	(a)	(a)
	Quito	column	(b)	(b)	(b)	(b)	(b)	(b)
Greenland:	Thule	column	(a)	(a)	(a)	.01	.01	.03
Iceland:	Keflavik	column	(b)	(b)	(b)	(b)	(b)	(b)
Mexico:	Mexico City	column	(b)	.01	(a)	(b)	.13	(b)
Peru:	Lima	column	(a)	(a)	(a)	(a)	(a)	(a)
Puerto Rico:	San Juan	column	.02	.02	(b)	.10	.19	.24
Venezuela:	Caracas (site 1)	column	.01	(a)	(a)	(a)	.03	.06
	Caracas (site 2)	column	(b)	(b)	.01	(a)	(b)	(a)

[a] Zero or trace.
[b] Data not available.

Table 4. Strontium-90 fallout in North and South America, HASL, July–December 1970

Sampling location		Type of collection	Deposition (nCi/m²)					
			July	Aug	Sept	Oct	Nov	Dec
Argentina:	Buenos Aires	column	0.04	0.04	0.08	0.08	0.05	(b)
	Formosa	column	.05	.06	(a)	.08	.04	(b)
	Malargue	column	.03	.02	(a)	.05	.07	(b)
Bahamas:	Bimini	column	.13	.04	.02	(a)	.02	(b)
Bermuda:	Kindley AFB	column	(b)	(b)	(b)	(b)	(b)	(b)
Bolivia:	Chacaltaya	column	.01	(b)	.04	.04	.03	0.01
	La Paz (city)	column	(a)	(a)	.03	.02	.02	.02
	La Paz (Ovejuyo)	column	(b)	(b)	.01	.01	.01	.01
Brazil:	Belem	column	.05	.03	.06	.02	.03	.02
	Rio de Janeiro	column	.03	.11	.15	.17	.17	(b)
	Trindade Island	column	.04	.06	.06	(b)	.08	(b)
Canada:	Moosonee	column	.18	.20	.14	.02	(b)	.04
Chile:	Antofagasta	column	(b)	(b)	(b)	(b)	.01	(a)
	Conception	column	(a)	.06	.06	(a)	(b)	(b)
	Easter Island	column	.03	.06	.02	.05	.02	.06
	Puerto Montt	column	.15	.10	.11	.10	.06	.14
	Punta Arenas	column	.03	.02	.02	.01	.01	(b)
	Santiago	pot	.05	.05	.06	.04	.01	.01
	Santiago	column	.12	.02	.05	.04	.01	.01
Colombia:	Bogota	pot	(b)	.01	(a)	(a)	(a)	(b)
Costa Rica:	Turrialba	column	.03	.02	.02	(a)	.02	.04
Equador:	Guayaquil	column	(b)	(b)	(b)	(b)	(b)	(b)
	Quito	column	(a)	(a)	(a)	.01	.01	.01
Greenland:	Thule	column	.13	(b)	(b)	(a)	.01	(b)
Iceland:	Keflavik	column	(b)	(b)	(b)	(b)	(b)	(b)
Mexico:	Mexico City	column	.14	.04	.03	(a)	(b)	(b)
Peru:	Lima	column	.02	.04	(a)	(a)	.01	.01
Puerto Rico:	San Juan	column	.08	.07	.05	.04	.03	.03
Venezuela:	Caracas (site 1)	column	.04	.02	.02	(a)	.02	(a)
	Caracas (site 2)	column	.02	(b)	(b)	(b)	(b)	(b)

[a] Zero or trace.
[b] Data not available.

REFERENCE

(*1*) ONG, L. D. Y. Homogeneity between pot and ion exchange column strontium-90 measurements. Fallout Program Quarterly Summary Report, HASL-135: 256-269. Office of Technical Services, Department of Commerce, Washington, D.C. (April 1, 1963)

SECTION IV. OTHER DATA

This section presents results from routine sampling of biological materials materials and other media not reported in the previous sections. Included here are such data as those obtained from human bone sampling, Alaskan surveillance, and environmental monitoring around nuclear facilities.

Environmental Levels of Radioactivity at Atomic Energy Commission Installations

The U.S. Atomic Energy Commission (AEC) receives from its contractors semiannual reports on the environmental levels of radioactivity in the vicinity of major Commission installations. The reports include data from routine monitoring programs where operations are of such a nature that plant environmental surveys are required.

Releases of radioactive materials from AEC installations are governed by radiation standards set forth by AEC's Division of Operational Safety in directives published in the "AEC Manual."[1]

Summary of the environmental radioactivity data follow for the Hanford Atomic Products Operation.

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[1] Title 10, Code to Federal Regulations, Part 20, "Standards for Protection Against Radiation" contains essentially the standards published in Chapter 0524 of the AEC Manual.

1. Hanford Atomic Products Operation[2] January–December 1969

Battelle Memorial Institute
Richland, Wash.

A variety of radioactive wastes are generated by the Hanford production reactors, chemical separations plants, and laboratories. High level wastes are concentrated and retained in storage within the project boundaries. Controlled releases of low-level wastes, for which concentration and storage are not feasible, are made to the ground, to the atmosphere, and to the Columbia River. The Atomic Energy Commission (AEC) regulations governing radioactive waste disposal at Hanford are described in the AEC Manual Chapter RL 0510 (*1*). During 1969, the plant facilities were operated for the Atomic Energy Commission by Atlantic Richfield Hanford Company; Pacific Northwest Laboratories of Battelle Memorial Institute; Douglas-United Nuclear, Incorporated; and ITT Federal Support Services, Incorporated.

The Hanford site is in a semiarid region of southeastern Washington State (figure 1) where the average rainfall is about 16 cm (6 inches). This section of the State has a sparse covering of natural vegetation primarily suited for grazing, although large areas near the site have gradually been put under irrigation during the past few years. The plant site covers an area of about 1,300 km^2 (500 square miles). The Columbia River flows through the northern edge of the project and forms part of the eastern boundary. Prevailing winds near the plant production sites are from the northwest, with strong drainage and cross winds causing distorted flow patterns. The meteorology of the region is typical of desert areas with frequent strong inversions occurring at night and breaking during the day to provide unstable and turbulent conditions.

The populated area of primary interest is the tri-cities area (Richland, Pasco, and Kennewick) situated on the Columbia River directly downstream from the plant. Smaller commu-

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[2] Summarized from Pacific Northwest Laboratory, "Evaluation of Radiological Conditions in the Vicinity of Hanford for 1969," BNWL—1505 (November 1970).

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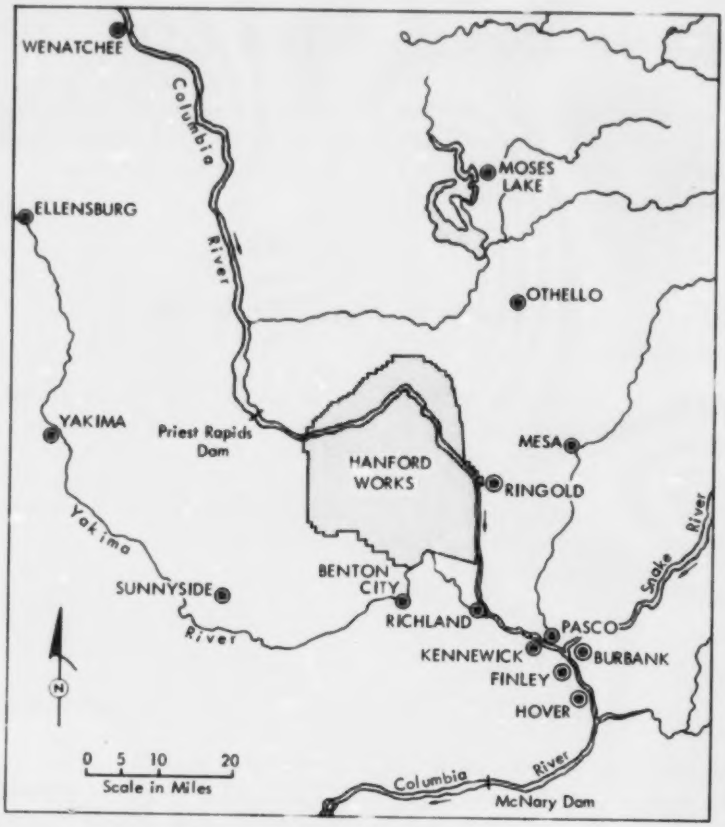
WENATCHEE
Columbia River
ELLENSBURG
MOSES LAKE
OTHELLO
YAKIMA
Priest Rapids Dam
HANFORD WORKS
MESA
RINGOLD
Yakima River
SUNNYSIDE
BENTON CITY
RICHLAND
PASCO
Snake River
KENNEWICK
BURBANK
FINLEY
HOVER
N
0 5 10 20
Scale in Miles
Columbia River
McNary Dam

Figure 1. Hanford project environs

nities in the vicinity are Benton City, West Richland, Mesa, and Othello. The population of the communities near the plant, together with the surrounding agricultural area, is about 100,000.

Sources and levels of environmental radioactivity

Low-level wastes from Hanford operations, fallout from nuclear weapons testing, naturally-occurring radioelements, and cosmic rays contribute to radioactivity in the Hanford environs. Hanford operations that could contribute to radioactivity outside the plant boundary are: (1) the disposal of reactor cooling water to the Columbia River, (2) stack releases at the chemical separations area and laboratory areas, and (3) disposal of radioactive wastes to ground.

The most significant Hanford contributions to off-plant radioactivity and population doses usually originate with reactor cooling water released to the Columbia River. Although airborne releases of iodine-131 have contributed in past years to the thyroid doses of the local population, the major portion of the thyroid doses in recent years has resulted from radioiodines in drinking water.

Noteworthy events during 1969 included the retirement in April of C reactor, the sixth Hanford production reactor to be retired since 1964. Three plutonium production reactors (including the dual-purpose N reactor) remained in operation. Increased atmospheric total beta concentrations observed during June–August were attributed to an announced foreign weapons test in December 1968 (*2*).

Radioactivity in the Columbia River

Nuclides present in reactor effluent

Cooling of the Hanford production reactors (with the exception of N reactor) is accomplished by a single pass of treated Columbia River water. The N reactor uses recirculating demineralized water as a primary coolant, and all wastewater containing significant amounts of radioactive material is discharged to a ground disposal site near the river. Although some of these radionuclides eventually enter the river, the total quantity of radioactivity entering the Columbia River from N reactor is a negligibly small fraction of that released from the older reactors.

At the older reactors, some elements present in the cooling water are activated during the single pass through the reactors. In addition, radioactive materials formed on the surfaces of fuel elements and process tubes are eventually carried away by the cooling water to the river. Table 1 shows the relative abundance of the radionuclides found in the cooling water of the older production reactors, adjusted to 4 hours after leaving the reactor.

Many of the radionuclides formed in reactor cooling water are short-lived and disappear quickly by radioactive decay. In addition, sedimentation and uptake by aquatic organisms remove some fraction of most radionuclides from the river water. Relatively small amounts of fission products are present in the river because of the fissioning of natural uranium present in the river water, occasional element cladding failures, and fallout from nuclear weapons testing.

Some radionuclides also enter the river from wastes disposed to ground, but their contribution to the total radioactivity was not detectable.

Table 1. Relative abundance of reactor effluent radionuclides[a]

Percent of abundance				
Major (90 percent)	Minor (9 percent)	Trace (1 percent)		
^{24}Na	^{32}P	^{3}H	^{91}Y[b]	^{143}Ce[b]
^{31}Si	^{46}Sc	^{14}C	^{93}Y[b]	^{144}Ce[b]
^{51}Cr	^{69m}Zn	^{35}S	^{95}Nb	^{142}Pr[b]
^{56}Mn	^{72}Ga	^{45}Ca	^{99}Mo	^{143}Pr[b]
^{64}Cu	^{76}As	^{54}Mn	^{103}Ru	^{147}Nd[b]
	^{92}Sr	^{59}Fe	^{106}Ru	^{147}Pm[b]
	^{122}Sb	^{60}Co	^{124}Sb	^{149}Pm[b]
	^{132}I	^{65}Ni	^{131}I	^{151}Pm[b]
	^{140}La[b]	^{65}Zn	^{133}I	^{152}Eu[b]
	^{152m}Eu[b]	^{87m}Sr	^{135}I	^{156}Eu[b]
	^{153}Sm[b]	^{89}Sr	^{136}Cs	^{153}Gd[b]
	^{165}Dy[b]	^{90}Sr	^{137}Cs	^{159}Gd[b]
	^{239}Np	^{91}Sr	^{140}Ba	^{160}Tb[b]
		^{90}Y[b]	^{141}Ce[b]	^{161}Tb[b]
				^{166}Ho[b]
				^{169}Er[b]
				^{171}Er[b]

[a] Trace nuclide composition based on analyses performed in 1964 and 1968.

[b] These radionuclides as a group are denoted hereafter as RE + Y (rare earths + yttrium).

River flow rates

The seasonal fluctuations in flow rate of the Columbia River affect radionuclide concentrations by varying the quantity of water available for dilution of reactor effluent released to the river. In addition, the seasonal scouring of sediments deposited in reservoirs behind each dam causes seasonal fluctuations in transport rates of those longer-lived nuclides associated with the sediments. This is notably true for scandium-46 and zinc-65. Also affected by the flow rate is the time required for a specific volume of water to move from one location to another, which in turn affects the amount of the shorter-lived radionuclides present at any specific location.

The weekly average flow rates of the Columbia River at Priest Rapids and Bonneville Dams are determined from daily average flow rates published by the U.S. Geological Survey (*3*). For 1969, the average flow rate at Priest Rapids was 3,830 m^3/s (135,000 ft^3/s) which was slightly above the 1948–1962 annual average of 3,770 m^3/s (133,000 ft^3/s).

River concentrations

During 1969, samples of river water were collected at Priest Rapids Dam (upstream from the production reactors) and below the reactors at the Richland water plant intake, McNary Dam, and Bonneville Dam. Where possible, cumulative sampling equipment was used to provide a more representative sample than periodic "grab" samples. This cumulative sampling technique, however, prevents calculation of the concentrations of radionuclides with very short half-lives; these were measured in monthly "grab" samples (*4*).

Table 2. Annual average concentrations of several radionuclides in Columbia River, 1966–1969

Radionuclide	Concentration (pCi/liter)							
	1966		1967		1968[a]		1969	
	Richland	Bonneville Dam	Richland	Bonneville Dam	Richland	Bonneville Dam	Richland	Bonneville Dam
Rare earths + yttrium	270	(b)	390	(b)	290	(b)	750	(b)
Hydrogen-3	(b)	(b)	1,500	(b)	1,700	(b)	1,900	(b)
Sodium-24	2,600	(b)	2,600	(b)	2,200	(b)	1,600	(b)
Phosphorus-32	140	23	190	25	92	15	73	14
Scandium-46	30	(b)	60	18	100	20	72	(b)
Chromium-51	3,600	1,300	3,200	1,400	1,500	530	720	240
Manganese-56	290	(b)	520	(b)	250	(b)	1,000	(b)
Copper-64	1,400	(b)	2,000	(b)	1,200	(b)	1,700	(b)
Zinc-65	200	43	220	62	86	<30	72	25
Arsenic-76	420	(b)	400	(b)	320	(b)	310	(b)
Strontium-90	1	(b)	1	(b)	<.6	(b)	<.5	(b)
Zirconium-niobium-95	(b)	(b)	(b)	<5	<6.3	(b)	<3.8	(b)
Technetium-99	(b)	(b)	<5	(b)	<11	(b)	<4.3	(b)
Ruthenium-106	(b)	(b)	(b)	<5	<5	(b)	<4.3	(b)
Antimony-122	(b)	(b)	150	(b)	150	(b)	90	(b)
Iodine-131	18	3	8	3	7.4	<3.2	4.0	(b)
Neptunium-239	776	(b)	1,100	(b)	1,000	(b)	1,100	(b)
Total alpha	<1.3	(b)	<1.2	(b)	[c] <1.3	(b)	<1.0	(b)

[a] During 1968, results for ^{3}H, ^{32}P, ^{46}Sc, ^{51}Cr, ^{65}Zn, ^{95}Zr-Nb, ^{90}Sr, and ^{131}I were based on cumulative samples.
[b] Indicates insufficient data to provide a meaningful annual average.
[c] Based on grab samples (January–June 1968) and on cumulative samples (July–December 1968).

Sampling traverses across the Columbia River at Richland have indicated a slightly nonuniform distribution of the longer-lived radionuclides at this cross section. Entries of the Yakima River just below Richland and of the Snake River just below Pasco influence the distribution of radionuclides in the Columbia below these two points. The magnitude of the influence varies with seasonal changes in the flow rates of the tributaries.

Table 2 shows the annual average radionuclide concentrations in river water at Richland and at Bonneville Dam for 1966–1969. The data for 1966 include the effects of reactor outages during the July–August strike. Comparison of 1969 with 1968 concentrations indicates a general reduction for most radionuclides. The concentrations of several radionuclides, however, increased during 1969; copper-64 concentrations increased slightly, while the rare earths plus yttrium group and maganese-56 showed significant increases. As in past years, total alpha concentrations measured in river water at Richland were near the analytical limit of 1 pCi/liter and were not significantly different from those measured in samples collected upstream from the Hanford plant.

Concentrations of tritium in river water are measured upstream from Hanford at Priest Rapids Dam (where fallout would be the only source of tritium) and downstream from Hanford at Richland. The average concentration of tritium at both Priest Rapids Dam and Richland in 1969 was 1.9 nCi/liter, which was slightly higher than the concentrations measured at these locations during 1968 (1.6 and 1.7 nCi/liter, respectively).

Bonneville Dam, approximately 390 km (240 miles) below the Hanford reactors, is the farthest downstream location where river water is routinely sampled as part of the Hanford environmental surveillance program. Measurements at this location provide a maximum level for the annual transport of specific nuclides into the Pacific Ocean (table 3).

Table 3. Annual average transport rates of selected radionuclides past Bonneville Dam, 1965–1969

Radionuclides	Transport rate (Ci/day)				
	1965	1966	1967	1968	1969
Phosphorus-32	11	9	12	6.2	7.1
Scandium-46	NA	NA	10	7.5	NA
Chromium-51	800	430	610	200	100
Zinc-65	49	21	40	<13	<15

NA, indicates no routine analysis was made.

Transport rates

Figures 2 and 3 show the river transport rates of several radionuclides past Richland. The transport rates at Richland in 1969 for

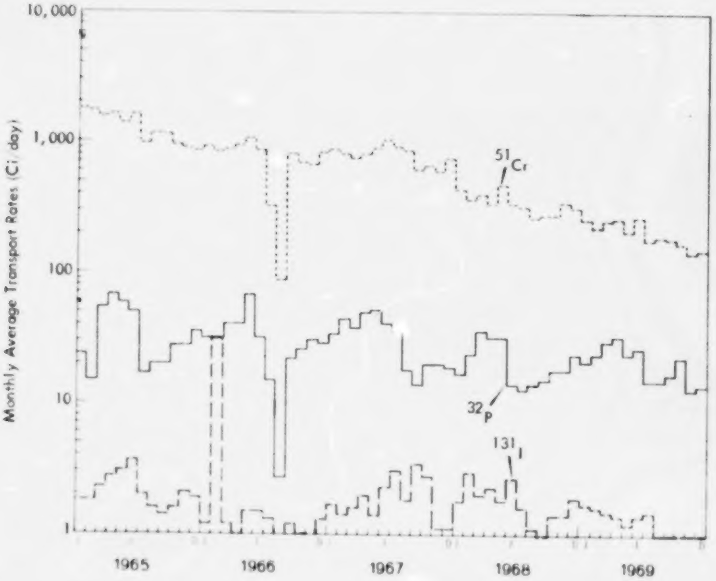

Figure 2. Phosphorus-32, chromium-51, and iodine-131 transport rates in the Columbia River at Richland, 1965–1969

the five radionuclides shown were all lower than the 1968 values, except for phosphorus-32 and zinc-65 which were comparable with the 1968 values. Table 3 shows the annual average transport rates of selected radionuclides past Bonneville Dam.

Trend indicator—whitefish

The Columbia River is popular for sport fishing both above and below the Hanford reservation. Fish feeding downstream from the reactors acquire some reactor-effluent radio-

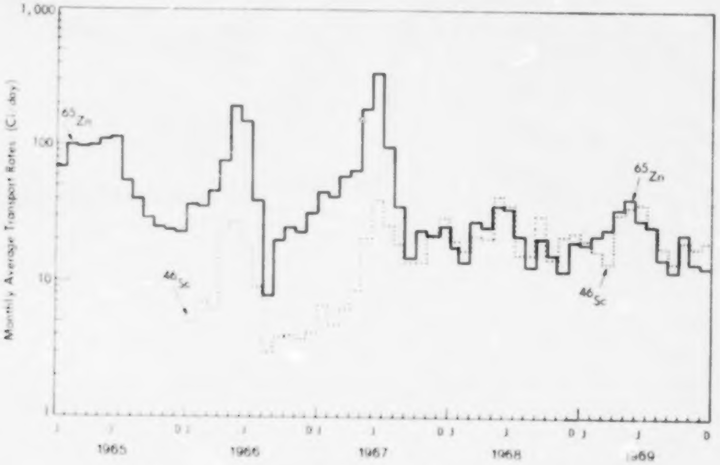

Figure 3. Scandium-46 and zinc-65 transport rates in the Columbia River at Richland, 1965–1969

nuclides, mostly through food chains, with phosphorus-32 being the most significant in regard to population doses. Changes in river concentrations and temperatures may induce changes in concentrations in biological media. However, the ultimate uptake of radionuclides depends on complex environmental interrelationships. Whitefish are the sport fish that usually contain the greatest concentration of radioactive materials. Furthermore, they can be caught during winter months when other sport fish are difficult to sample. Therefore, phosphorus-32 data accumulated from whitefish sampling near the plant boundary are useful as a trend indicator of concentrations in biological media even though whitefish are not the most significant source of radionuclides for the local population.

Concentrations of phosphorus-32 in whitefish during 1969 tended to follow the same seasonal trends observed in past years. But the average phosphorus-32 concentration in fish in 1969 was much lower than expected based upon phosphorus-32 concentrations in the river and river temperatures. The average concentration of phosphorus-32 in whitefish sampled downstream from the reactors during 1969 was 34 pCi/g wet weight as compared with 140 pCi phosphorus-32/g wet weight during 1968 (*5*).

Radioactivity in ground water

Radioactivity in the ground water beneath the Hanford project results primarily from ground disposal of wastes in the chemical separations areas. These wastes are routed to various facilities, dependent upon their radionuclide burden and chemical content. High-level wastes[4] are stored in underground concrete tanks lined with steel. Intermediate-level wastes[5] are sent to underground "cribs" (covered liquid waste disposal sites) from which they percolate into the soil. The areas selected for intermediate-level waste disposal and high-level waste storage have soil with good ion exchange capacity and ground water depths of 50 to 100 m. Low-level wastes[6] are usually sent to depressions in the ground where surface ponds or "swamps" have been formed as the result of the continuous addition of relatively large volumes of water.

One important objective in the management of wastes placed in the ground is the prevention of radiologically important radionuclides from reaching the ground water in quantities that could ultimately cause significant human radiation exposure should they migrate to the Columbia River. An extensive ground water surveillance program is maintained at Hanford to aid in achieving this objective. Hundreds of wells have been drilled at various locations around the Hanford project, including sites within and near crib and tank storage areas, to monitor the movement of radionuclides in the ground water.

The radioactivity in ground water from the chemical separations areas outside the immediate vicinity of the disposal sites is primarily tritium and ruthenium-rhodium-106; cobalt-60 and technetium-99 have also been found but at much lower concentrations. The more radiotoxic nuclides, such as strontium-90, have not been detected in ground water except in the immediate vicinity of a few specific disposal sites.

Figures 4 and 5 show the probable extent of detectable tritium and ruthenium-rhodium-106 in ground water beneath the Hanford project as of December 31, 1969 (*6*). The outer boundaries of the contamination contours, e.g., 0.03 percent of the AEC standard for tritium and 2 percent of the AEC standard for ruthenium-rhodium-106, represent the detection levels routinely achievable for these radionuclides (*1*).

It is possible that some radionuclides from the chemical processing areas are presently entering the Columbia River. However, the concentrations of these nuclides are too small to be routinely measurable in the ground water near the river or in the river itself, and any radiation dose from them is negligible.

Radioactivity in the atmosphere

At Hanford, gaseous wastes from the chemical separations facilities are released to the atmosphere through tall stacks after most of the radioactive material has been removed. Laboratory stacks, reactor-building stacks, and

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[4] High-level: >100 μCi/ml.

[5] Intermediate-level: 50 pCi/ml to 100 μCi/ml.

[6] Low-level: <50 pCi/ml.

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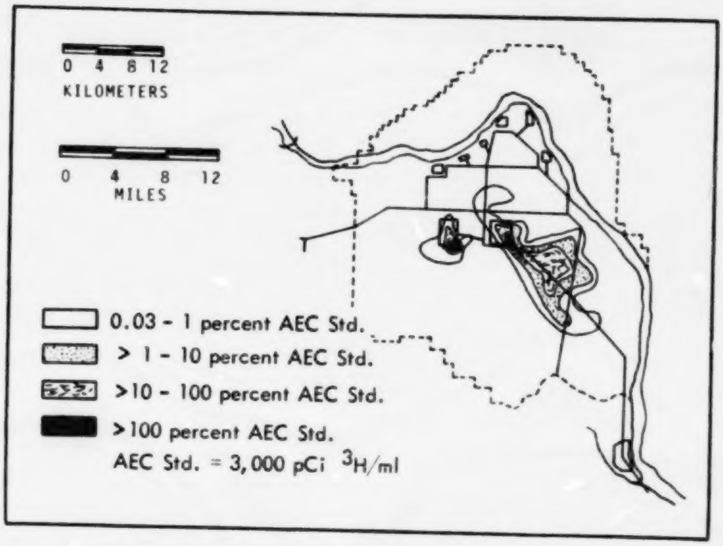
0 4 8 12
KILOMETERS
0 4 8 12
MILES
0.03 - 1 percent AEC Std.
> 1 - 10 percent AEC Std.
>10 - 100 percent AEC Std.
>100 percent AEC Std.
AEC Std. = 3,000 pCi ^{3}H/ml

Figure 4. Tritium concentrations in ground water, Hanford, 1969

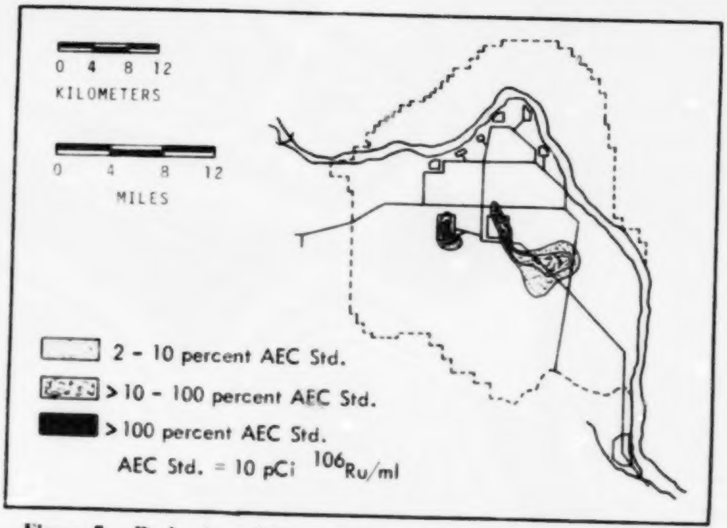
0 4 8 12
KILOMETERS
0 4 8 12
MILES
2 - 10 percent AEC Std.
>10 - 100 percent AEC Std.
>100 percent AEC Std.
AEC Std. = 10 pCi ^{106}Ru/ml

Figure 5. Ruthenium–106 concentrations in ground water, Hanford, 1969

stacks from waste storage facilities release relatively minor amounts of radioactive materials under normal operating conditions.

Measurements of airborne iodine-131, the radionuclide of primary interest, were made (as of the end of 1969) at 25 locations within and near the Hanford reservation. The results of iodine-131 measurements for four selected locations for the past few years, which include contributions from offsite weapons tests, are summarized in table 4. The locations listed in table 4 lie within a 90° sector southeast of the separations areas. The iodine-131 concentrations for 1969 averaged 0.01 pCi/m³ at Richland and Pasco. The annual thyroid dose from inhalation of iodine-131 at 0.01 pCi/m³ for the

Table 4. Annual average iodine-131 concentrations in the atmosphere, 1965–1969

Location	Distance from separation stacks (km)	Iodine-131 [a] (pCi/m³)				
		1965	1966	1967	1968	1969
Ringold [b]	21	(b)	(b)	0.02	0.02	0.02
Benton City	32	0.03	<0.02	.02	<.02	<.02
Richland	32	.02	<.02	.02	.02	<.02
Pasco	51	.03	<.02	.02	.02	<.02

[a] AEC standard—100 pCi/m³ for an individual infant in an uncontrolled area, assuming a 2-gram thyroid and a daily intake of 3,000 liters of air.
[b] Air sampling at Ringold began in January 1967.

2-gram thyroid would be less than 1 mrem,[7] based on appropriate metabolic parameters (*8*) and assuming that the fractional uptake from inhalation is invariant with age.

Continuous sampling for radioactivity associated with airborne particulates was maintained as of the end of 1969 at 34 locations, including those within the Hanford reservation and around the plant perimeter at distances up to 120 km (75 miles). The gross beta activity of each sample filter after exposure was routinely measured (based on strontium-yttrium-90) with detailed radioanalyses performed on filters showing unusual beta activity.

The higher atmospheric concentrations of radioactive particulate material during June–August 1969 compared to the early part of the year were attributed primarily to fallout following a foreign nuclear weapons test in late December 1968. The principal gamma emitters found on filters during June–August were zirconium-niobium-95, cerium-praseodymium-144, and ruthenium-rhodium-106. The concentrations were comparable to those observed during similar events of recent years.

Fallout from nuclear weapons tests

Airborne fallout was detected during most of the spring and summer of 1969. Increases were attributed to the announced foreign nuclear weapons test on December 27, 1969 (*9*). Total beta concentrations in the atmosphere began increasing in March and reached a peak of about 1 pCi/m³ in June and again in late July-early August. Iodine-131 concentrations in the atmosphere remained at or below the analytical limit (0.02 pCi/m³). Slightly increased concentrations of iodine-131 in milk during March (maximum - 8 pCi/liter) were not attributed to this test because of the long time lag.

No significant contribution to atmospheric radiation levels was detected following the announced foreign nuclear weapons tests of September 22 and 29, 1969 (*9*).

Exposure pathways

Radionuclides in drinking water

The city of Richland is the first community downstream (about 75 km) from the Hanford reactors that uses the Columbia River as a source of drinking water. Pasco and Kennewick, a few kilometers farther downstream, also use the Columbia River as a source of drinking water. The Richland and Pasco water plants use a modern flocculation-filtration treatment method; Kennewick water is pumped from Ranney well collectors (infiltration pipes) laid in the riverbank. During 1969, cumulative drinking water samples were collected at the Richland and Pasco water plants, and periodic samples, at all three communities. The Richland and Pasco samples were analyzed for selected individual radionuclides. Detailed analyses of drinking water from these two cities are summarized in table 5. In June, routine sampling at Kennewick was discontinued because of low gross beta radioactivity. Previous experience had shown that concentrations of radionuclides in Kennewick water were significantly lower than at Pasco or Richland.

The concentrations of short-lived radionuclides in the water at the time it is consumed are less than shown in table 5 because there can be a significant transport time between the water plant and most consumers. The transport time may vary from hours to days depending upon the location of the customers on the distribution system and the water demand. In Richland, many residents receive no radioactivity of Hanford origin in drinking water during the times of the year when well water is used to supplement the system supply.

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[7] A sustained concentration of iodine-131 at this level in breathing air would imply an annual radiation dose to the thyroid of the standard man (*7*) that would also be less than 1 mrem.

Table 5. Average concentrations [a] of several radionuclides in drinking water, 1969

Radionuclide	Radioactivity concentration (pCi/liter)	
	Richland	Pasco
Rare earths + yttrium	50	24
Sodium-24	1,200	350
Phosphorus-32	35	23
Scandium-46 [b]	24	37
Chromium-51	660	600
Copper-64 [b]	350	69
Zinc-65 [c]	34	30
Arsenic-76	99	38
Antimony-122	56	43
Iodine-131 [c]	3.4	3.3
Iodine-133	[d]20	[e]13
Neptunium-239	450	250
Total beta (counts/min/ml)	2.0	1.2

[a] Measured at the water plants.
[b] January-June average.
[c] Results based on cumulative samples.
[d] Estimate based on an average ratio of $^{133}I/^{131}I$ of 6:1 measured in grab samples.
[e] Estimate based on an average ratio of $^{133}I/^{131}I$ of 4:1 measured in grab samples.

Table 6. Calculated annual doses [a] to selected organs from routine ingestion of drinking water, 1969

Location	Whole body (mrem)	GI tract (mrem)	Bone (mrem)	Thyroid (infant) (0.4 liters/day) (mrem)
Richland	1.8	17	5	24
Pasco	.7	14	3	18

[a] In previous years an intake rate of 1.2 liters/day based on standard man was assumed. The revised intake rate (1.86 liters/day) is used for estimating doses received by the "average" Richland (adult) resident, based on local dietary surveys.
[b] Doses for this station were not adjusted for radioactive decay or dilution in the water distribution system.

Table 6 presents calculated doses to the adult bone, whole body, and GI tract from sustained consumption at an intake rate of 1.86 liters per day,[8] and to the infant 2-gram thyroid from consumption of 0.4 liters per day of drinking water in Richland and Pasco. Annual average concentrations of radionuclides measured at the water plants were used to calculate these doses. The correlation between the GI-tract dose rate at the water plant (established by direct measurement of individual radionuclide concentrations) and the gross beta activity was determined monthly. The correlation used in conjunction with thrice-weekly measurements of gross beta radioactivity at the water plant provided the basis for estimation of the GI-tract dose.

The dose estimates for Pasco residents reflect a downward trend from previous years. The thyroid dose for 1969 from Pasco drinking water (18 mrem) was significantly less than that for 1968 (32 mrem) because of decreased radioiodine concentrations. The average ratio of iodine-133 to iodine-131 of 4:1 for Pasco was based on 1968 measurements on grab samples because the extremely low concentrations of both radionuclides observed in grab samples during 1969 prevented direct measurement of the ratio.

The estimated GI-tract dose to Richland residents from the measured radionuclides in drinking water was somewhat lower in 1969 (17 mrem) than in 1968 (28 mrem). This resulted from the generally decreased concentrations of most measured radionuclides, as well as from the use of well water for over 99 percent of the city water supply in January, when the water filter plant was temporarily shut down. Well water contributed between 4 percent and 61 percent of the total supply in other months. However, radionuclide concentrations measured at the water plant (not adjusted for radioactive decay or dilution in the water distribution system) were used for the dose estimates shown in table 6. The infant thyroid dose during 1969 was about one-half that during 1968 (5) because of the decreased concentrations of radioiodines.

Radionuclides in Columbia River fish

The quantities and kinds of fish caught by local fishermen have been previously estimated from surveys carried out from 1961 to 1965 in cooperation with the Washington State Game Department. The maximum estimate of consumption by the fishermen interviewed was 200 meals per year of panfish species (crappie, perch, and bass) taken from the Columbia River. Additional dietary data collected during 1966 and 1967 from household questionnaires and interview surveys also showed individual consumption estimates as high as 200 meals of fish per year.[9] The primary fishing locations for the catch of these fish were Burbank, Hover-Finley, and Island View. The average percentage of the maximum annual consumption by species was 73 percent crappie, 16 percent bass, and 11 percent perch. Based on data collected during 1969, the average concentration of phosphorus-32 in such a mixture of panfish was about 12 pCi/g, and that of zinc-65 was 5.5 pCi/g.

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[8] In previous years, an intake rate of 1.2 liters/day based on standard man was assumed. The revised intake rate (1.86 liters/day) is used for estimating doses received by the average Richland adult resident, based on local dietary surveys.

[9] Fisherman survey by J. K. Soldat, Battelle-Northwest, Richland, Wash. (report in preparation).

From this species distribution and radiochemical analyses of the specimens collected, the "maximum individual's" estimated intakes during 1969 were 0.47 μCi phosphorus-32 and 0.22 μCi zinc-65 (*9*) which are about one-half the corresponding intakes during 1968.

The average consumption of Columbia River fish by Richland residents was estimated from plant employee diet questionnaires (*10*). With the use of the same mixture of species as for the "maximum individual," the "average Richland resident's" intake during 1969 was 0.006 μCi phosphorus-32 and 0.003 μCi zinc-65. These intakes correspond to a bone dose of about 1 mrem or about 0.2 percent of the standard of 500 mrem per year for the population average. For comparison, intakes during 1968 were 0.012 μCi phosphorus-32 and 0.004 μCi zinc-65.

Radionuclides in game birds

Waterfowl and other game birds utilizing the river downstream from the reactors or open low-level waste disposal sites within the plant boundaries may contain phosphorus-32, zinc-65, and other radionuclides as a result of ingestion of insects, algae, vegetation, and water containing these radionuclides, and could be a significant exposure pathway for persons who consume such birds. Some waterfowl remain in this general area throughout the year. The concentrations of radionuclides in game birds at the time of consumption are dependent upon the bird species, the geographical locations of the birds, their current feeding habits, and the elapsed time between killing and consumption of the birds.

For the past 3 years, about 16 km^2 (4,000 acres) of the Hanford reservation situated north of Ringold on the eastern side of the Columbia River have been opened to hunters during hunting season. This area, which is adjacent to the river, was visited in 1969 by 3,050 hunters for an average of about 63 hunters on each of the 48 open days. The U.S. Fish and Wildlife Service has estimated that 3,400 waterfowl, 50 pheasants, 45 quail, and 20 chukar were harvested (*11*). For comparison, the average number of hunters for 1968 was about 33 on each of the 46 open days with a harvest of 1,037 waterfowl, 16 pheasant, 75 quail, and 3 chukar (*12*).

The average concentration of phosphorus-32 in the muscle (the edible portion) of waterfowl collected at the Hanford site for the environmental monitoring program during 1969 was about 72 pCi/g for 46 ducks and 3.6 pCi/g for 12 geese. The maximum concentration in such waterfowl during 1969 was 510 pCi phosphorus-32/g, which is not significantly different from the maximum observed in 1968 for birds collected in the same area.

In addition to the birds collected on the river, nine waterfowl were sampled from swamps and a trench within the plant boundaries. Seven of the samples were collected from swamps receiving low-level liquid wastes near the chemical separations areas. The muscle of these birds contained on the average 34 pCi phosphorus-32/g and less than 1 pCi zinc-65/g. The predominant radionuclide in birds utilizing these swamps, cesium-137, was detected in concentrations ranging from 70 to 420 pCi/g and averaging 300 pCi/g. For comparison, cesium-137 was detected in the muscle of only one waterfowl collected on the river, with a concentration of 1.4 pCi/g, which was considerably below the typical range of concentrations observed in muscle of waterfowl collected from swamps near the chemical separations areas. If an adult had consumed one-half pound of the bird containing the maximum cesium-137 concentration found in muscle from birds collected on the Hanford swamps during 1969, the resulting estimated radiation doses would be 8 mrem for the skeletal bone and 6 mrem for the whole body, about 1 percent of the appropriate standards for individual members of the public.

Near the 100-K reactor area, two waterfowl were collected in late December from a trench

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utilized for the temporary retention of reactor cooling water. As expected, the same radionuclides were found in these ducks as were normally found in birds collected on the river. However, because the sources of radioactivity for birds collected from the trench were derived from undiluted reactor cooling water rather than water diluted by the Columbia River, concentrations significantly higher than those in river birds were possible. The predominant radionuclide in the muscle of these two birds, phosphorus-32, was found at 0.003 and 0.110 μCi/g. Immediate consumption of one-half pound of the latter duck (ingestion of a little less than 25 μCi of phosphorus-32) would result in a radiation dose of 4.7 rem to the skeletal bone of a standard man (*13*). However, the consumption of such a bird by any member of the public is considered to be unlikely in view of the fact that very few birds (of over 200,000 in the area) would be likely to spend sufficient time in the trenches near the reactor areas to accumulate such large amounts of radioactive materials. Any delays between the time a bird left a trench and the time of shooting or resulting from the frequent practice of freezing game birds for later consumption would permit radioactive decay and would further reduce the probability of consuming flesh containing the high concentrations of phosphorus-32. For example, in the case we have considered here, a delay of 4 weeks would have reduced the skeletal bone dose to less than 1,500 mrem (the annual standard). As in past years, it is our judgment that ducks collected on swamps, trenches, or ponds are not representative of those available to the general population and that dose estimates derived therefrom are not pertinent for comparison with the established dose standards. Action taken by the reactor-operating contractor to prevent recurrence consisted of screening and partially filling the trenches in the two operating reactor areas. This work to prevent access to the water surfaces was completed in the spring of 1970.

Table 7. Average phosphorus-32 and zinc-65 concentrations[a] in muscle of river birds, 1969

Species	Concentration (pCi/g)	
	Phosphorus-32	Zinc-65
Duck	72	5.1
Goose	3.6	8.3
Quail	19	2.0
Pheasant	18	2.7
Chukar[b]	5	3.1

[a] Waterfowl collected on the Columbia River and other birds collected within 5 km (3 miles) of the river within the Hanford boundary.

[b] Estimate based on past data and comparison with quail.

Average concentrations in muscle for upland game birds collected at the Hanford site appear in table 7. The maximum phosphorus-32 concentration in upland game bird muscle was 340 pCi/g in a pheasant sample. For comparison, the maximum phosphorus-32 concentration in similar samples in 1968 was 490 pCi/g in a quail sample.

Data from a dietary survey of Hanford employees and from a special survey of local hunters and concentration data for the various species have been combined in tables 8 and 9 (*9, 10, 14*). About 30 percent of the game bird meals consumed by local hunters were reported to be birds shot within 5 km (3 miles) of the Columbia River between Ringold and McNary Dam. Past analyses have shown that pheasants collected beyond this distance con-

Table 8. Species distribution of local game birds, 1969

Distribution	Percent					
	Duck	Goose	Quail	Pheasant	Grouse	Dove
River birds[a] of each species	37	32	19	33	8	20
Meals of each species of all bird meals	23	6	12	47	13	No data
River bird meals of each species of all bird meals	8.5	1.8	2.3	16	<1	No data

[a] River birds are defined to be birds shot within 5 km (3 miles) of the Columbia River between Ringold and McNary Dam.

Table 9. Contribution[a] of each species to 100 grams of an average game bird meal, 1969

Species	Weight (grams)	Radionuclide content (pCi)	
		Phosphorus-32	Zinc-65
Duck	23	344	43
Goose	6	4	16
Quail	12	25	5
Pheasant	47	156	42
Grouse	13	3	3
Total	100	530	110

[a] Weighted for location of kill by using measured concentrations for river birds and assuming no phosphorus-32 or zinc-65 in other birds. Also weighted for frozen storage by assuming complete decay of phosphorus-32 but no significant decay of zinc-65 during frozen storage of 44 percent of the birds.

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tain little, if any, radioactivity of Hanford origin. About 44 percent of all birds eaten were reported to have been placed in frozen storage, which would permit appreciable decay of any phosphorus-32 before consumption.

The maximum total game bird consumption by adults reported to date is 100 meals per year, which we assume to be about 23 kg/a. Consumption of this weight of the average game bird meal (table 8) would result in intakes of 0.12 μCi phosphorus-32 per year and 0.03 μCi zinc-65 per year, implying 23 mrem to the skeleton of a "standard man" or less than 2 percent of the standard for individual members of the population with bone as the critical organ. Consumption of the estimated annual intake (1.24 kg/a) for the "average Richland resident" (adult) would result in intakes of 0.006 μCi phosphorus-32 and 0.001 μCi zinc-65, implying a total dose of about 1 mrem to the skeleton or less than 1 percent of the appropriate standard (500 mrem/a).

Radionuclides in shellfish

Zinc-65 and phophorus-32 are the only radionuclides in the reactor effluent that are found in sufficient abundance in food organisms beyond the mouth of the Columbia River to be of radiological interest. Oysters have been found to contain higher concentrations of zinc-65 than other common seafoods (*15*). Monthly average concentrations of zinc-65 and phosphorus-32 were periodically measured in oysters grown commercially in the Willapa Bay area. A normal seasonal minimum for phosphorus-32 occurs in the late summer. In 1969, phosphorus-32 average concentrations remained at or below 1 pCi/g from August through December, as in 1968. The annual average concentrations for 1969 were 19 pCi zinc-65/g and 2.8 pCi phosphorus-32/g.

Consumption of oysters containing the 1969 average concentrations at the rate of 50 g/day would result in annual doses of about 4 mrem to the GI tract, 3 mrem to the whole body, and 11 mrem to the bone of a standard man (*13, 16*). Fresh shellfish are not an important item in the average tri-cities diet, but residents of some coastal areas may consume more than the reference value of 50 g/day. For such individuals, shellfish are assumed to be their only source of radionuclides of Hanford origin.

Radionuclides in milk and produce

Irrigation with river water containing reactor effluent radionuclides can influence the radioactivity found in locally grown products. Deposition of airborne materials from Hanford sources and from fallout can be an additional source of radionuclides in these products. Chemical separations facilities are generally the principal local source of airborne radionuclides, although radioactive materials released from ventilation stacks of reactor or laboratory facilities could, under certain conditions, be of interest.

The farming areas closest to the separations facilities is at Ringold about 21 km (13 miles) away. However, much of the land east and south of the project boundary is under cultivation and may be in the path of airborne releases.

Most irrigated farms near the Hanford plant obtain water from the Yakima River, or from the Columbia River above the plant. However, two small irrigated areas using Columbia River water taken downstream from the reactors are the Ringold farms and the Riverview district, west of Pasco. They are 40 and 65 km (25 and 40 miles) respectively, downstream from the operating reactors. The Ringold farms, about 21 km east of the separations areas, involve some 20 people working 2 km^2 (500 acres) of land with fruit as the principal product. The Riverview district comprises about 21 km^2 (5,200 acres) supporting about 1,000 families, the majority of which live on plots of 2,500 m^2 (1 acre) or less and raise family gardens. The principal products from the larger farm plots are hay, fruit, beef, and dairy products. This area is centered, 40 km (25 miles) southeast of the chemical separations plants.

The milk surveillance program maintained during 1969 included samples from local farms and dairies and from commercial supplies available to people in the tri-cities. The concentrations of radionuclides found in milk sold by commercial outlets were similar to those re-

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ported by the U.S. Public Health Service and the Washington State Department of Health (*17, 18*). Milk from local farms irrigated with water drawn from the river downstream from the reactors contained phosphorus-32, zinc-65, and iodine-131, as well as fission products of fallout origin. Commercial milk distributed in the tri-cities usually does not contain detectable phosphorus-32 or zinc-65 because only a small fraction of the milk is produced on farms irrigated with water drawn from the Columbia River below the Hanford reactors.

In 1968 and 1969, river-irrigated farms were sampled only in Riverview. Although two farms were sampled during a few months of 1969, the majority of the concentrations of phosphorus-32 and zinc-65 for this Riverview farm were 160 and 110 pCi/liter compared to 310 and 130 pCi/liter, respectively, for the same farm in 1968. Seasonal fluctuations in concentrations of both phophorus-32 and zinc-65, caused primarily by irrigation and feeding practices, followed expected trends.

During 1969, iodine-131 concentrations in both farm milk and commercial milk were generally near or below the analytical limit (3 pCi/liter). The maximum iodine-131 concentration for the period (8 pCi/liter) was measured in a single sample of farm milk collected on March 11, 1969. The average concentration for the year in farm milk was <1.3 pCi iodine-131/liter.

Adult residents consuming milk (1 liter/day) obtained from the Riverview area could have received an annual dose from phosphorus-32 and zinc-65 amounting to about 2 mrem to the GI tract, 1 mrem to the whole body, and 11 mrem to the bone. The same intake of milk by a child with a 2 kg skeleton would result in an estimated bone dose of 39 mrem.[10] The intake of iodine-131 would have resulted in a dose of about 8 mrem to the 2 g thyroid of an infant.

Miscellaneous fresh produce from local farms was sampled periodically for radioanalysis during the 1969 growing season. Results of these measurements were similar to those of previous years and indicated that only small quantities of radionuclides are present in locally-grown produce. Specifically, the concentrations of iodine-131 found in samples of fresh leafy vegetables collected from local farms and markets during May through September were less than or approximately equal to the analytical limit of 0.05 pCi/g.

External radiation

Clusters of three ionization chambers (Victoreen stray radiation chambers) located 1 meter above the ground level on the Hanford reservation and in Richland, measure the gamma radiation exposure from external sources. Data for January 1969 were lost. Data collected during the remainder of the year indicated slightly higher average exposures at both locations as compared to 1968 values. For 1969, the measured exposure averaged about 140 mR/a at Hanford and 110 mR/a at Richland. Essentially all of the exposure at Richland is from natural background and worldwide fallout from nuclear testing.

Estimates of the external radiation dose received from recreational use of the Columbia River in the vicinity of the Hanford project are based on routine measurements at the river shoreline at Richland and Sacajawea Park and below the surface of the river at Richland. The shoreline measurements are made with a large (40 liter) ionization chamber set 1 m back from the water's edge and 1 m above the ground to approximate the dose rates to the gonads of a person on the riverbank. The measured exposure rates include components from radioactivity accumulated in sediment deposits and algal growths at the river's edge as well as from radioactive material in the water. Gamma spectra have shown that scandium-46 and zinc-65 were the major contributors to the shoreline component, and sodium-24 to the water component. Daily and seasonal fluctuations in the river flow rate affect the shoreline radiation levels in several ways including changes in the volume of water diluting the reactor effluent, in the time required for short-lived radionuclides to reach downstream locations, and in the amount of sediment exposed. Other seasonal variations may reflect such things as changes in parent nuclides (such as the spring increase in manganese-56) or in

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[10] Based on dose factors of 660 mrem/μCi for ^{32}P and 11 mrem/μCi for ^{65}Zn for the 2 kg skeletal weight.

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biological cycles (shoreline insect deposits of debris). For the panfish species consumed in the largest quantities, the primary fishing locations are downstream from Richland. The radiation dose received by fishermen while fishing these locations is estimated from measurements at Sacajawea Park, where the Snake River enters the Columbia.

An avid fisherman (such as the maximum individual), standing on the shoreline at Sacajawea Park for as much as 500 hours during 1969, could have had a gonad exposure to external gamma radiation of Hanford origin of 8.5 mR (about 2 percent of standard for whole body).

The immersion dose received by tri-city swimmers is based on April through October exposure rates at Richland, measured with clusters of five pocket-type ionization chambers positioned about 1 meter below the surface of the Columbia River. Measured immersion exposure rates were primarily due to the gamma emitters (especially sodium-24) introduced into the river with reactor cooling water. In the vicinity of Richland, the average immersion exposure rate during April through October 1969 was 2.7 mR/day. Because the contribution of natural background external radiation during immersion would be quite small relative to the inaccuracies of the measurement, the measured immersion exposure rate is attributed entirely to radioactivity of Hanford origin.

In 1968, teenagers were recognized as the major recreational users of the river. A survey of 430 Richland teenagers indicated an average exposure time of about 115 hours in or along the river for members of this group. About one-third of the time was probably immersion and about two-thirds was shoreline exposure.[11] Using the annual average shoreline exposure rate and the April through October average immersion exposure rate at Richland, the average exposure to the teenage population was estimated to be about 6 mR during 1969. This was somewhat higher than in 1968 because of the slightly increased immersion exposure rate.

The exposures to teenagers who reported considerably greater river exposure time than the average were estimated. The 38 teenagers reporting 300 hours or more per year of Columbia River recreation time were taken to be representative of the critical population group for this exposure pathway. The estimated exposures to external radiation of Hanford origin for individual members of this group ranged from 8 to 53 mR, with an average of about 23 mR. Expressed as whole body dose, this average (23 mrem) for the critical population group with respect to external exposure represents less than 5 percent of the appropriate standard (500 mrem/a) for critical individuals.

The average whole body dose received by the Richland population from recreational use of the Columbia River can be estimated by assuming that other age groups use the river less than teenagers, but with the same proportion of immersion and shoreline exposure times. For the average exposure of the Richland population, an annual Columbia River (recreation) time of 32 hours was assumed. Based on 11 hours of immersion and 21 hours of shoreline exposure in the vicinity of Richland,[12] the whole body dose received by the average Richland resident during 1969 was estimated to be about 2 mrem, or about 1 percent of the appropriate standard of 170 mrem/a.

Fallout from nuclear weapons tests

Dose increments received by residents of the Hanford environs from the fallout nuclides tritium, strontium-90, and cesium-137, have been estimated routinely, although they are not included in the assessment of dose due to Hanford operations. The concentrations of fallout nuclides in the local environs are below the national average because of the low rainfall. Measurements of fallout, like measurements of natural background radiation, help to put the radiation doses resulting from Hanford operations in proper perspective.

Unlike previous years, no increase of iodine-131 concentrations in milk attributable to fallout from weapons testing were observed during 1969, even though foreign weapons tests were conducted in late December 1968 and September 1969 (*9, 19*).

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[11] Unpublished shoreline data by D. H. Denham, Battelle-Northwest, Richland, Wash. (1969).

[12] Unpublished recreational use data by J. F. Honstead, Battelle-Northwest, Richland, Wash. (1969).

Estimates of tritium intake from drinking water were based on concentrations measured in river water. Concentrations of strontium-90 in locally produced farm and commercial milk are similar to those in commercial milk produced in other areas of low rainfall remote from the Hanford plant (*17*). Strontium-90 in locally produced commercial milk averaged 3.4 pCi/liter during 1969, slightly below that in 1968. Concentrations of cesium-137 averaged below the analytical limit of 30 pCi/liter for both types of milk worldwide. Worldwide fallout is the primary source of strontium-90 and cesium-137 in milk.

Assuming that 40 percent of the total strontium-90 intake from fallout is obtained from milk, the daily intake of strontium-90 during 1969 was estimated to be 12 pCi/day for the "maximum individual" and 4 pCi/day for the "average Richland resident" (adult) (*20*). These values are similar to the intakes estimated for 1968 (10 and 5 pCi/day, respectively). The total intake of cesium-137 during 1969 was about 0.03 μCi for the "maximum individual," and 0.009 μCi for the "average adult Richland resident." These intakes are also similar to those for 1968.

Table 10 shows a summary of the estimated annual dose commitments from fallout nuclides present in the Hanford environs. The strontium-90 intakes are also evaluated in terms of the Federal Radiation Council guides (*7*) for the maximum individual and the average Richland resident. Both correspond to 2 percent of the FRC intake guides for the upper end of Range II.

Table 10. Annual radiation dose from fallout radionuclides,[a] 1969

Radionuclide	Organ	Radiation dose (mrem) "Maximum" individual	Radiation dose (mrem) "Average" Richland resident
Tritium	Whole body	<1	<1
Strontium-90 [b]	Whole body	[b]4	[b]1
	GI tract	<1	<1
	Bone	[b]37	[b]12
Cesium-137	Whole body	[c]2	[c]<1
	GI tract	<1	<1
	Bone	2	<1
Total	Whole body	5	2
	GI tract	<1	<1
	Bone	39	13

[a] Not included in dose summaries presented elsewhere.

[b] The radiation dose commitments shown for bone and whole body represent the dose received over a period of 50 years based on ICRP methods. Only a few percent of the total dose commitment from strontium-90 intake is received during the first year for each of these organs.

[c] For the whole body dose commitment from ingestion of cesium-137 by an adult, the FRC dose conversion factor of 0.06 rem/μCi was used. In previous reports the factor 0.031 rem/μCi based on ICRP values was used. The principal reason for the difference in the two factors is a change in the value for biological half life of cesium-137 from 70 to 100 days in the adult.

Composite estimates of radiation dose

The maximum individual

Experience accumulated from the environmental surveillance program and associated research studies indicates that those individuals receiving the greatest percentage of permissible radiation dose from Hanford sources consume some combination of the following: fish caught locally in the Columbia River, game birds shot near the river, foodstuffs produced on local farms irrigated with Columbia River water drawn from below the reactors, and municipal water with the Columbia River as the source. A hypothetical "maximum" individual has been assigned assumed dietary habits (table 11) which are identical to those used in the 1966, 1967, and 1968 annual reports (*5, 10, 21*).

The consumption rates of most foods for this hypothetical "maximum" individual were compiled from intake rates described in pub-

Table 11. Dietary assumptions, 1969

Foodstuffs	"Maximum" individual	"Average" (adult) Richland resident
Water	730 liter/a	[a]680 liter/a
Milk	380 liter/a	[a]130 liter/a
Meat	80 kg/a	[a]74 kg/a
Chicken	8 kg/a	[a]5.4 kg/a
Eggs	30 kg/a	15 kg/a
Seafood	[d]0	[a,b]1.4 kg/a
Columbia River fish	40 kg/a	[a].48 kg/a
Game birds	[d]0	[a]1.2 kg/a
Leafy vegetables	[c]73 kg/a	36.5 kg/a
Other vegetables and fruits	[c]530 kg/a	200 kg/a
	"Maximum" individual (infant)	"Average" (infant) Richland resident
Water	0.8 liter/day	0.4 liter/day
Milk	1.0 liter/day	.6 liter/day
Leafy vegetables	50 g/day	25 g/day

[a] Based on dietary questionnaires of Richland residents employed at Hanford

[b] One-tenth of the total is assumed to be Willapa Bay oysters, the remainder free of radionuclides of Hanford origin.

[c] Fresh produce from the Riverview area is assumed to be available only during 5 months of the year.

[d] Insignificant amount and figures in the table are weighted to reflect this fact.

lished dietary surveys and have been documented separately in detail (*22, 23*). The postulated sources include water from the Pasco municipal system and milk, meat, and produce from river-irrigated farms in the Riverview district. The consumption of fish (200 meals per year of panfish taken from the Columbia River) and the total time spent along the river bank to catch these fish (500 hours per year) are based on the values reported in local surveys.

The composite doses estimated for this "maximum" individual are summarized in table 12 and illustrated in figure 6. Decreases were noted for all estimated organ doses with the largest decreases being for the infant thyroid and the adult bone doses.

Table 12. Summary of radiation doses in the Hanford environs,[a] 1968-1969

	1968		1969		Standard (mrem)
	Annual dose (mrem)	Percent of standard	Annual dose (mrem)	Percent of standard	
Maximum individual:					
Bone	250	17	140	9	1,500
Whole-body	24	5	18	4	500
GI tract	62	4	40	3	1,500
Thyroid (infant)	110	7	60	4	1,500
Average Richland resident:					
Bone	13	3	15	3	500
Whole-body	3	2	4	2	170
GI tract	25	5	19	4	500
Thyroid (infant)	39	8	23	5	500

[a] Doses from fallout and natural background not included.

The estimated bone dose received by the maximum individual in 1969 was 140 mrem (9 percent of the appropriate standard) derived from both radionuclide intake and external radiation. About 66 percent of the bone dose resulted from ingestion of Columbia River fish and about 6 percent from exposure to shoreline radiation while fishing. About 9 percent of the total bone dose was derived from milk, 6 percent from eggs, 4 percent from fruit and vegetables, 3 percent from meat, 3 percent from chicken, and about 3 percent from drinking water. A single radionuclide, phosphorus-32, accounted for 92 percent of the total bone

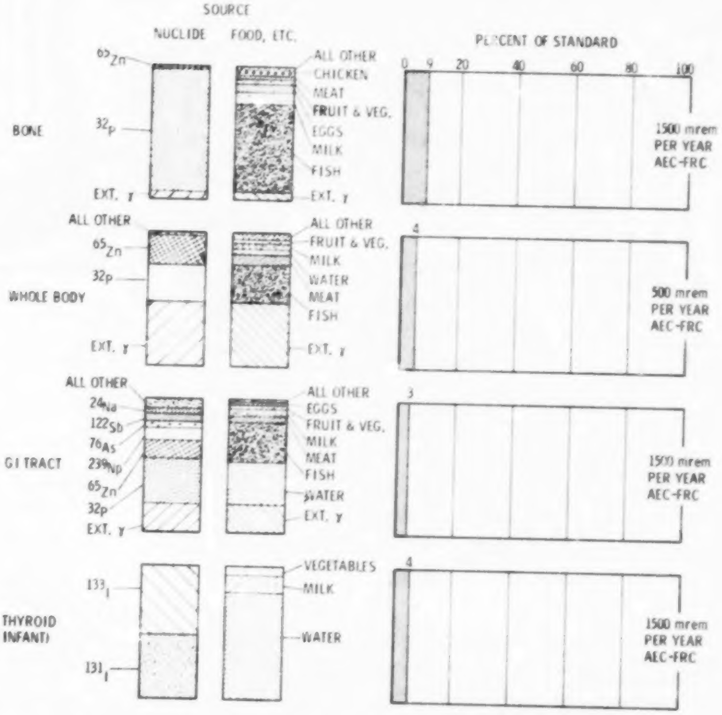

Figure 6. Estimated doses to the "maximum" individual, 1969

dose. For comparison, the 1968 estimated bone dose was 250 mrem (17 percent of standard).

The whole body dose estimate for 1969 for the "maximum" individual was 18 mrem (4 percent of the standard), somewhat lower than the 1968 estimate of 24 mrem (5 percent of the standard). For 1969, about 48 percent of the whole body dose resulted from exposure to shoreline radiation while fishing.

The estimated dose to the GI tract for the maximum individual during 1969 was 40 mrem (3 percent of standard), also lower than the 1968 estimate of 62 mrem (4 percent of standard). In 1969, the principal sources were drinking water, panfish, and external radiation contributing 32 percent, 30 percent, and 21 percent of the total dose, respectively.

The highest radiation doses to human thyroids are those received by infants because of the relatively small thyroid mass (assumed to be 2 grams). For the purpose of estimating thyroid dose for comparison with the standard, the maximum individual is defined as an infant drinking water with radionuclide concentrations equal to those at the Richland water plant and consuming food and milk obtained from commercial sources. Dietary assumptions for 1969 (table 11) were identical to those in 1968 and 1967.

The estimated thyroid dose for such an infant in 1969 was 60 mrem (4 percent of the standard), which is significantly less than the 1968 estimate of 110 mrem (7 percent of the standard). This decrease resulted from a decrease in the measured concentrations of iodine-131 in Richland drinking water in 1969. Measurements of monthly grab samples of drinking water during 1969 indicated the same ratio of concentrations of the short-lived iodine-133 to iodine-131 (6:1) that was observed in 1968. The annual average iodine-133 concentration was estimated by multiplying the annual average iodine-131 concentration in cumulative samples by the average measured iodine-133 to iodine-131 ratio. In 1969, iodine-133 and iodine-131 in drinking water contributed 52 percent and 28 percent of the maximum individual (infant) thyroid dose. Iodine-131 in milk and in leafy vegetables accounted for the remainder.

Table 13 shows the significant decreases in estimated doses to the maximum individual over the years 1965 to 1969, with organ doses adjusted to a comparable basis where necessary to clarify trends. The long-term trend for all organ doses is obviously downward. The bone doses from ingested radionuclides only are shown, because, although exposure to shoreline radiation had been assumed for previous years, no external radiation contribution to the bone dose was evaluated until 1968, when radionuclide intakes were evaluated in terms of mrem rather than expressed as a percentage of the maximum permissible rate of intake (MPRI). The thyroid doses shown are those from intake of iodine-131 only, because iodine-133 contributions were not routinely evaluated until 1967, although iodine-133 was undoubtedly present in drinking water to some extent in previous years.

Table 13. Dose estimates for "maximum" individual 1965 to 1969[a]

Organ	Percent of standards					Standard (mrem)
	1965	1966	1967	1968	1969	
GI tract[b]	6	5	5	4	3	1,500
Whole-body[b]	8	7	6	5	3	500
Bone	24	22	24	[c]16	[c]8	1,500
Thyroid (infant)	4	6	[d]3	[d]3	[d]2	1,500

[a] Does not include contributions from fallout and natural background radiation.

[b] The annual dose contributions to the whole-body and GI tract from external radiation for the years 1965 through 1969 were estimated to be 15, 13, 11, 9.5, and 8.5 mrem and have been included in the doses listed for these organs.

[c] For comparison, bone doses from ingested radionuclides are shown for all years although in 1968 and 1969, a contribution from external radiation was included in the total bone dose estimates.

[d] For comparison, the thyroid doses listed are from iodine-131 only, although in 1967, 1968, and 1969, a contribution from iodine-133 was included in the thyroid dose estimate.

The "average" Richland resident

Estimates of average consumption rates of several food items were obtained for Richland adults from analysis of dietary questionnaires completed by plant employees. The program and the data have been discussed in another report (*10*). Table 11 includes a summary of the diet for the "average" Richland resident whose food is assumed to come from commercial sources.

In computing doses for the "average" Richland resident, the assumed food sources were

Richland drinking water with average concentrations adjusted for radioactive decay and dilution, Columbia River fish with the average species composition of fish ingested by the "maximum" individual, "average" game birds, and milk, meat, and produce from local stores.

Because no significant contribution from Hanford operations to the background radiation levels in Richland can be discerned, the external dose to the "average" Richland resident is assumed to result only from recreational use of the Columbia River. An estimated dose increment of 2 mrem from immersion in the river and activities along the shoreline was included in the GI tract, whole-body, and bone doses. No such increment was included in the thyroid dose which is calculated for the infant because of the limited use of the river by this age group.

The composite doses estimated for the "average" Richland resident for 1969 (figure 7) are summarized in table 12 with 1968 estimates for comparison. The 1969 doses estimated for the GI tract of the "average" Richland resident and for the thyroid of the "average" Richland infant decreased significantly. No significant differences between 1968 and 1969 dose estimates were noted for the bone and whole body.

The estimated bone dose received by the "average" Richland resident in 1969 was 15 mrem (3 percent of the standard) derived from both radionuclide intake and (as in 1968) external radiation. About 25 percent of the total bone dose was derived from drinking water, 24 percent from meat, 13 percent from external radiation, 13 percent from milk, 8 percent from game birds, 7 percent from panfish, 6 percent from seafood, and 4 percent from remaining food items. A single radionuclide, phosphorus-32, accounted for 85 percent of the total bone dose. For comparison, the 1968 estimated bone dose was 13 mrem (3 percent of the standard).

The whole-body dose estimate for 1969 was

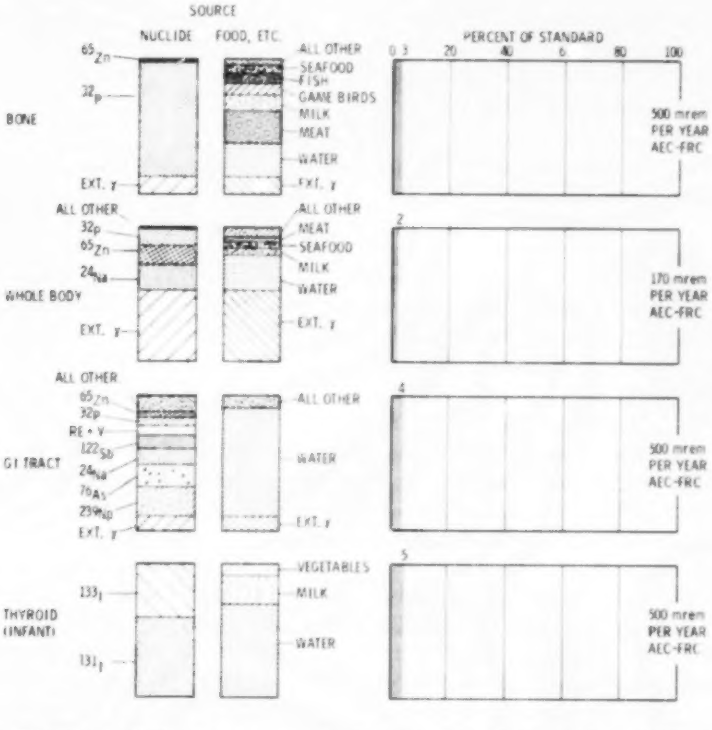

Figure 7. Estimated doses to the "average" Richland resident, 1969

4 mrem (2 percent of the standard), not significantly different from the 1968 estimate of 3 mrem (2 percent of the standard). For 1969, about 53 percent of the whole body dose resulted from recreational use of the Columbia River.

The estimated dose to the GI tract for the "average" Richland resident during 1969 was 19 mrem (4 percent of the standard), somewhat lower than the 1968 estimate of 25 mrem (5 percent of the standard). As in 1968, the principal source was drinking water (81 percent of the total 1969 dose).

The "average" Richland infant is defined as an infant drinking Richland municipal water, with radionuclide concentrations adjusted for radioactive decay and dilution. Dietary assumptions for 1969 were identical to those used in 1968 and 1967.

The estimated thyroid dose for such an infant in 1969 was 23 mrem (5 percent of the standard), significantly less than the 1968 estimate of 39 mrem (8 percent of the standard). This decrease resulted from decreased concentrations of radioiodines in Richland drinking water, which was, as in 1968, the principal source of radioiodines. In 1969, iodine-133 and iodine-131 in drinking water contributed 40 and 30 percent, respectively, of the "average" Richland infant's thyroid dose. Iodine-131 in milk and in leafy vegetables accounted for the remainder.

Conclusions

The Hanford environmental surveillance program for 1969 indicated that most of the environmental radiation dose for the majority of persons living in the Hanford environs was due to natural sources and worldwide fallout rather than to Hanford operations. The major source of low-level wastes released to the environment from Hanford operations continued to be reactor cooling water discharged to the Columbia River. During 1969, radiation doses of Hanford origin were less than one-tenth of the appropriate dose standards and reflected a general decrease from comparable 1968 values for most organs. The gradual shutdown of Hanford facilities has contributed to the decrease in environmental doses over the past few years.

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Republic of France Nuclear Detonations, 1960–1971

Table 1 lists the reported nuclear detonations for the Republic of France from 1960 to 1971. The first nuclear explosions were held in Algeria, and from November 1961 to February 1966, a series of tests was conducted in the Sahara Desert. During 1963 to 1966, France developed a center for testing nuclear weapons in the islands of Tuamotu Archipelago in the South Pacific Ocean (*1*) in the region of the Tropic of Capricorn, approximately 4,000 miles to the east of Australia (*2*).

France did not sign the test ban agreement forbidding nuclear explosions in the atmosphere.

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Table 1. Republic of France nuclear detonations, 1960–1971

Date of detonation	Type	Yield	Location
2/13/60	Tower	60–70 kilotons	[a]Reggan, Algeria
4/1/60	Surface	Small	Reggan, Algeria
12/27/60	Tower	Small	Reggan, Algeria
4/25/61	Tower	Small	Reggan, Algeria
11/7/61	Underground	Weak	[b]5.03.07E., 24.03.25N
5/1/62	Underground	Middle	5.02.30E., 24.03.46N
3/18/63	Underground	Weak	5.03.07E., 24.02.28N
3/30/63	Underground	Weak	5.03.25E., 24.02.36N
10/20/63	Underground	Middle	5.02.19E., 24.02.07N
2/14/64	Underground	Weak	5.03.08E., 24.03.13N
6/15/64	Underground	Weak	5.02.04E., 24.03.59N
11/28/64	Underground	Weak	5.02.30E., 24.02.30N
2/27/65	Underground	Middle	5.01.52E., 24.03.31N
5/30/65	Underground	Weak	5.03.03E., 24.03.18N
10/1/65	Underground	Weak	5.02.02E., 24.03.53N
12/1/65	Underground	Weak	5.02.48E., 24.02.37N
2/16/66	Underground	Weak	5.02.28E., 24.02.39N
7/2/66	Barge	Small	Mururoa Island
7/19/66	Air	Small	Mururoa Island
9/11/66	Balloon	Small	Mururoa Island
9/24/66	Barge	Small	Fangataufa Island
10/4/66	Barge	200–300 kilotons	Mururoa Island
6/5/67	Balloon	Small	Mururoa Island
6/27/67	Balloon	Small	Mururoa Island
7/2/67	Balloon	Small	Mururoa Island
7/7/68	Balloon	Small	Mururoa Island
7/15/68	Balloon	0.5 megaton	Mururoa Island
8/3/68	Balloon	Low-intermediate	Mururoa Island
8/24/68	Balloon	Low megaton (First H-bomb)	Fangataufa Island
9/8/68	Balloon	Low megaton	Mururoa Island
5/15/70	Balloon	Low	Mururoa Island
5/22/70	Balloon	Intermediate	Mururoa Island
5/30/70	Balloon	Intermediate (Megaton range)	Fangataufa Island
6/24/70	Balloon	Low	Mururoa Island
7/3/70	Balloon	Intermediate (One megaton)	Mururoa Island
7/27/70	Balloon	Low	Mururoa Island
8/2/70	Balloon	Low-intermediate	Fangataufa Island
8/6/70	Balloon	Intermediate	Mururoa Island
6/5/71	Balloon	Low [c]	Mururoa Island
6/12/71	Balloon	Intermediate [c]	Mururoa Island
7/4/71	Balloon	Low [c]	Mururoa Island
8/8/71	Balloon	Low [c]	Mururoa Island
8/14/71	Balloon	Intermediate [c]	Mururoa Island

[a] First test of a nuclear device, tower was 350 feet high.
[b] Location of tests for which coordinates are given is the Sahara Desert.
[c] Approximate yield; low, 0–100 kilotons, intermediate, 100–1,000 kilotons.

Reported Nuclear Detonations, November 1971

(Includes seismic signals from foreign test areas)

The U.S. Atomic Energy Commission conducted a nuclear detonation of a <5 megaton device (named Cannikin), about 5,875 feet under the surface of Amchitka Island in the Aleutian Chain of Alaska at 11:00 a.m., Bering Sea time (5:00 p.m., EST), Saturday, November 6, 1971. A report from the Palmer Observatory indicated that on detonation, a reading of 7.0 on the Richter scale occurred, as predicted.

No large earthquake was triggered by the detonation, although hundreds of aftershocks much smaller in recorded magnitude than the shock wave from the explosion were registered in the vicinity of the detonation until the cavity created by the detonation collapsed to the surface (this occurred about 38 hours after the test). No aftershocks were observed after cavity collapse. A preliminary survey of the surface subsidence indicated that it had a maximum depth of about 60 feet, with a radius of approximately 2,600 feet. When surface collapse occurred, seismic instruments at Palmer, Alaska, recorded the resulting earth disturbance as having a Richter magnitude (surface wave) of about 5.0.

When Cannikin was detonated, natural ocean wave activity was high in the Amchitka region because of very strong winds the previous day. No tsunami or large ocean wave produced by ocean floor movement was observed or recorded.

The tundra surface in the ground zero area was considerably cracked and otherwise disturbed, as had been expected. Two ponds in the area were drained and three others partially drained. Cliff and turf falls along the Bering Sea for a 2-mile stretch near ground zero were greater than had been predicted, and preliminary indications are that the beach and ocean floor in the near vicinity of the Cannikin site has been lifted permanently by several feet.

Cliff and turf falls along the Pacific Ocean side of the island appeared to be approximately as predicted.

The dike of a pond holding drilling mud, about 4.7 miles from ground zero, developed cracks from Cannikin ground motion, and an estimated 5,000 cubic yards of drilling mud escaped before the cracks were sealed. Most of the mud flowed into a small creek that empties into the Pacific Ocean, with the inflow being at a point about one and a half miles from the ocean. On the basis of other experience, it must be assumed that organisms in the affected portion of the creek were destroyed.

Searches of the seashores of Amchitka located and recovered the bodies of 14 dead sea otters. Two additional injured otters were observed from helicopters, but these animals could not be recovered. Another two abandoned small otter pups were seen but not recovered. Assumption was made that all these died, making a total of 18 (16 on the Pacific side and two on the Bering side).

Twelve of the 14 recovered sea otter bodies underwent autopsies. Deaths of seven appeared to be from overpressure in water, two died from rockfalls, and three apparently were fatally injured by vertical acceleration (upthrust of the ground).

Aerial counts have indicated a lessened number of sea otters in the Bering Sea near the Cannikin site as compared with before the test. The water there is muddied for some distance out because of siltation from turf falls into the water. On the Pacific Ocean side of Amchitka and along other parts of the Bering coast, it appeared that normal numbers of sea otters were observed.

Four dead seals were found in the searches and their autopsies showed that all apparently died from overpressure.

Autopsies of 16 dead birds found on the island indicated that all but one died of the effects of the explosion, seven from overpressure

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and eight from vertical acceleration. No eagles or peregrine falcons were among the dead birds. Three or four bald eagle nesting sites along the Bering coast apparently were lost in cliff falls, and two on the Pacific coast. One eagle nesting site on each coast appeared unstable and subject to weather damage. No peregrine falcon nesting sites used in 1971 were lost, but one used in 1969 and 1970 was believed gone.

Hundreds of dead fish were found on beaches, most of them greenling which live around the kelp beds fringing Amchitka. A scuba survey of ocean bottom areas near ground zero on both the Pacific and Bering sides of the island indicated no significant difference in numbers of sea urchins from before the test. Hundreds of dead fresh water fish were found on the borders of small lakes near Cannikin ground zero. Most were sticklebacks (a small trash fish) and a great many of them were in patterns, indicating their kill came from gale winds the day before Cannikin. Some Dolly Varden Char (a game fish) were also found dead.

There has been no detectable release of radioactivity to the marine or surface environment as a result of Cannikin. Measurements will continue for a number of years.

China set off an atmospheric nuclear explosion at approximately 1:00 a.m., EST, November 18, 1971, in the vicinity of Lop Nor. The yield was about 20 kilotons.

A nuclear test in the yield range of less than 20 kilotons was conducted underground on Wednesday, November 24, 1971, by the Atomic Energy Commission at its Nevada Test Site.

The nature of the scientific experiment involved the possibility of a very small release of radioactivity. A seepage of radioactivity did occur about 4 hours after the test was conducted. Aircraft and ground radiation monitoring teams kept track of the radioactivity as it dispersed. A very small amount of radioactivity was detected south of the Nevada Test Site, a few miles east of Lathrop Wells, immediately adjacent to the site. No radiation readings above background have been obtained on the ground off the test site, however, monitoring and environmental sampling are continuing. The level of radiation detected in the air was only slightly above normal background. There is no health hazard either on or off the Nevada Test Site.

Seismic signals, presumably from a Soviet underground nuclear explosion, were recorded by the United States today. The signals originated at approximately 1:00 a.m., EST, November 29, 1971, at the Semipalatinsk nuclear test area and were equivalent to those of an underground nuclear explosion in the intermediate yield range of 20-200 kilotons.

Not all of the nuclear detonations in the United States are announced immediately, therefore, the information in this section may not be complete. A complete list of announced U.S. nuclear detonations may be obtained upon request from the Division of Public Information, U.S. Atomic Energy Commission, Washington, D.C. 20545.

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SYNOPSES

Synopses of reports, incorporating a list of key words, are furnished below in reference card format for the convenience of readers who may wish to clip them for their files.

IMPACT OF TRITIUM ON THE WATCH INDUSTRY, 1966–1970.

F. J. Bradley, R. Blais and A. Jones. Radiological Health Data and Reports, Vol. 12, November 1971, pp. 601–610.

Tritium contamination from self-luminous watches at wholesale importers, retailers, and refinishers has been investigated. Air, surface-wipe, and urine samples were analyzed for tritium content by liquid scintillation counting to determine the extent of the contamination.

Eleven storage vaults were surveyed, and the highest human exposure (0.5 rem per year) was found in a firm which handled approximately 200 Ci/a and had poor vault ventilation. Contamination was negligible in vaults at retail establishments.

The casing and repair areas of a firm which handled more than 100 Ci/a had air, surface, and human contamination values of 0.063 pCi/cm^3, 11,200 pCi/100 cm^2, 0.48 μCi/liter, and 0.039 pCi/cm^3, 7,820 pCi/100 cm^2, and 0.22 μCi/liter, respectively, on a yearly average. The casing and repair areas of a firm which handled about 10 Ci/a had air, surface, and human contamination values of background, 430 pCi/100 cm^2, and 0.08 μCi/liter, and background, 807 pCi/100 cm^2, and 0.05 μCi/liter, respectively, on a yearly average.

A refinisher who handled an estimated 30-50 Ci/a had air, surface, and human contamination values of background, 33,600 pCi/100 cm^2 (near stripping solution), and background, respectively, on a yearly average.

KEYWORDS: Dial painting, New York, promethium-147 radium, tritium, watches.